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Seasonal Variation in the Chemical Facies of Turonian-Coniacian Waters Exploited in the Benn-Togo Sedimentary Basin

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Abstract

Hydrogeochemistry of the Turonian-Coniacian aquifer was studied over the northern part of the Benin-Togo Coastal Sedimentary Basin to enhance groundwater facies knowledge, mineralization processes, and probable interactions between groundwater and surface water. The study employed geochemical analyses and hydrochemical diagrams which revealed that groundwater chemistry changes seasonally and differs between Benin and Togo. In Benin, bicarbonate-type waters dominated during the dry season, while chloride-type waters were more common during the rainy season. Sodium chloride waters dominated in the dry season in Togo, whereas bicarbonate waters were more prevalent in the rainy season. Three main processes controlling water mineralization were identified in this study as follows: dissolution/concentration, impacts from human activities, and ion exchange mechanisms. Hierarchical Cluster Analysis (HCA) further showed evidence of probable interconnection between groundwater and surface water in both seasons. Ultimately, the study improved understanding of the aquifer system and provided useful information for a sustainable water resource management in the Benin-Togo Coastal Sedimentary Basin, while highlighting the need for further lithostratigraphic and isotopic studies.

Keywords

Hydrogeochemistry, Geochemical Facies, Turonian Coniacian, Benin-Togo Coastal Sedimentary Basin

1. Introduction

The variation in global water resources is linked to climate change and population growth. According to [1], the aquifers of the coastal sedimentary basin of the Gulf of Guinea, extending from Ghana to Nigeria, are under increasing human pressure. Population settlements in this area are often not accompanied by the implementation of basic sanitation systems, meaning that human activities threaten the quality of water resources in general, and groundwater resources in particular. Only half of the freshwater contained in groundwater (0.3% of the total water on Earth) is accessible to humans for direct consumption [2]. Consequently, population growth, agricultural development, and increasing industrialization in these countries have led to greater exploitation of groundwater resources and high levels of human-caused pollution. Water quality deterioration is often irreversible, at least in shallow aquifers. Benin and Togo are not spared from these difficulties.

In both Togo and Benin, groundwater constitutes a significant part of the country's water resources, and access to drinking water for the population is a major concern for the government. For decades, these countries have developed adequate water infrastructure to guarantee a drinking water supply for rural communities.

Togo shares the coastal sedimentary aquifer with Ghana, Benin, and Nigeria; there are no significant transboundary problems. Benin and Togo are characterized by fairly similar hydrogeological situations. The Benin-Togo coastal sedimentary basin, defined from a geometric point of view, contains productive aquifer levels separated by aquiclude formations [3]. The hydrogeology of these coastal sedimentary aquifers has been studied for about thirty years [4]-[6].

Groundwater resources, primarily located in deep aquifers, are often relatively resistant to pollution. However, for deep aquifers with outcropping zones experiencing increasing population settlement, their vulnerability to pollution warrants careful consideration. This is the case for the deep aquifers of the coastal sedimentary basin of Benin and Togo (Kéta Basin), particularly the Upper Cretaceous aquifer. This aquifer is the deepest (oldest) and outcrops in the northern part of the basin, specifically on the northern plateaus, thus exposing it to pollution. The work of [3] and [7], addressing the piezometrics of the Turonian-Coniacian aquifer, shows that its recharge zone is located north of the northern plateaus of the Benin-Togo Sedimentary Basin, where it outcrops.

The following questions urgently need to be addressed:

1) Is the water in the wells drawn from these outcrop zones contaminated or polluted?

2) Are there any connections between surface water and the Turonian-Coniacian reservoir?

3) How can we assess the risk of contamination of this deep groundwater, which is exposed at the surface in some areas?

Hydrogeochemistry is an important discipline in the work of hydrogeologists. The concentrations of chemical compounds present in water depend on the water's origin, the geological formations it has passed through, and the time it has spent in these formations. Groundwater mineralization has been extensively studied [7]-[12].

The overall objective of this work is to evaluate the geochemical functioning of Turonian-Coniacian aquifers. Specifically, it aims to assess the aquifer's vulnerability to contamination; to determine the mineralization process of Turonian-Coniacian groundwater in the coastal sedimentary basin of Benin-Togo; and to understand the dynamics of surface water-groundwater exchange for integrated water resource management.

2. Study Area

The coastal sedimentary basin occupies the southern tip of both countries, with the Mono River marking the border. Known in Togo as the Togolese Coastal Sedimentary Basin, it covers an area of approximately 3300 km^2, representing 6% of the national territory. In Benin, it is known as the Beninese Coastal Sedimentary Basin and covers an area of approximately 11,476 km^2, representing 10% of the national territory [13]. The Benin-Togo Coastal Sedimentary Basin (BSCB-T) covers a total area of approximately 14,776 km^2 and is bounded to the north by outcrops of its bedrock (Pan-African crystalline basement) and extends southward into the offshore portion under the Atlantic Ocean, widening from west to east, from the border between Ghana and Togo to that between Benin and Nigeria.

The Turonian-Coniacian aquifer, which is the subject of our study, outcrops in the north of the Benin-Togo Coastal Sedimentary Basin on the four northern plateaus of Benin (Kétou, Zagnanado, Abomey, and Aplahoué) and the three of Togo (Kouvé, Tchévié, and Fogbé) [3]. The region, subject to a sub-equatorial climate, is characterized by two distinct rainy seasons linked to the movement of the Intertropical Convergence Zone (a longer rainy season from mid-March to July and a shorter rainy season from mid-September to November) and two dry seasons from August to mid-September and from December to mid-March, respectively.

Geomorphologically, the coastal sedimentary basin of Benin-Togo is organized, on either side of the NNE-SSW-oriented Lama depression, into a series of sloping plateaus dissected by river valleys. This basin is drained by the main rivers: the Zio, Haho, Mono, Couffo, Zou, and Ouémé. From a geological perspective, the Keta Basin, spanning the Benin-Togo region, comprises sedimentary formations (sands, gravels, sandy clays, clays, marls, and limestones) ranging from the Cretaceous to the Quaternary periods. These formations exhibit a monoclinal structure characterized by differential subsidence, increasing towards the SSE [14].

The sedimentary aquifers of the coastal basin (Keta Basin) are multilayered aquifers, generally exhibiting high productivity. The Coastal Sedimentary Basin comprises four aquifer units separated by thick aquicludes of low permeability. These aquifers range from the youngest to the oldest: the Quaternary sand aquifer, the Mio-Pliocene sand aquifer, the Paleocene limestone aquifer, and the Upper Cretaceous (Turonian-Coniacian) sand aquifer. The Quaternary and Mio-Pliocene aquifers are shallow and can be accessed with large-diameter wells. The Paleocene and Cretaceous aquifers are deep, but the Cretaceous aquifer is unique in that it outcrops in the northern part of the coastal basin, from where it is recharged.

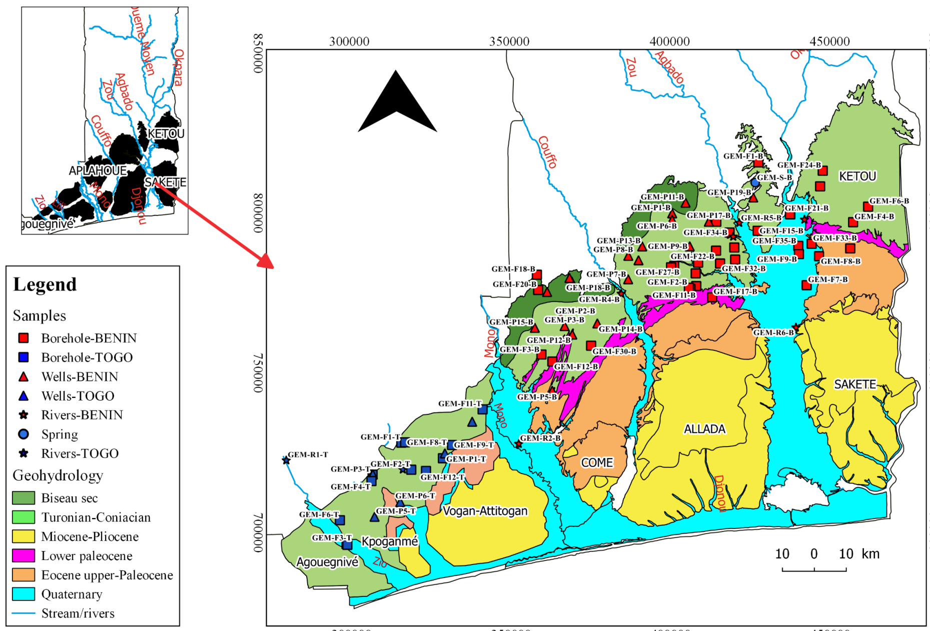


Figure 1. Location of the study area showing sampling points (first campaign March 2023) and hydrogeological information (modified from GIZ, 2012).

3. Materials and Methods

3.1. Sampling and Measurements

To assess the water quality of the studied reservoir, surface water samples (from rivers) and groundwater samples (from hand-dug wells, boreholes, and a spring) were collected. Initially, using the Integrated Database (IDB) of boreholes in Benin, we ensured that only boreholes and hand-dug wells tapping the Turonian-Coniacian aquifer were selected for sampling. It is important to remember that the reservoir studied in this research is the deepest and oldest in the Benin-Togo Coastal Sedimentary Basin [14] [15]. It is very deep and very difficult to access in the southern part of the Basin but outcrops in the north [3] [7], which reassured us regarding the use of the Integrated Borehole Database. A total of two field campaigns were conducted. For the first campaign, seventy-four (74) samples were collected (19 in Togo and 55 in Benin). Water from boreholes and wells tapping the Turonian-

Coniacian aquifer and seven (7) surface water samples (March 2023: low water) were collected (**Figure 1**). During the second sampling campaign, which took place in July 2023 (high water), the number of samples collected was reduced due to the inaccessibility of some sites during the flood season. This limited us to a total of fifty-six (56) samples (14 in Togo and 42 in Benin). Our seasonal comparative study was conducted at these 56 sampling points during the flood season, which were also sampled during the first campaign. It should be noted that before any sampling, the boreholes were purged to obtain a representative sample of the groundwater [7]. We allowed the borehole water to drain for a few minutes. For the first campaign at the end of the dry season, for each sampling point For the water samples, we collected them in 1 L polyethylene bottles, which were transported in ice-filled coolers to the Waste Management, Treatment, and Recovery Laboratory at the Faculty of Sciences, University of Lomé, Togo (for water samples collected in Togo) and to the Applied Hydrology Laboratory (LHA) at the National Water Institute of the University of Abomey-Calavi, Benin (for water samples collected in Benin) for analysis. For the second campaign during the rainy season, samples from each water point were collected in 1 L polyethylene bottles for analysis in Togo. Those collected in Benin were stored in 350 mL bottles for transport to the Geology Department of the Faculty of Sciences and Techniques at Cheikh Anta Diop University in Dakar, Senegal, for analysis. **Figure 2** below shows the spatial distribution of the sampled points for the second campaign.

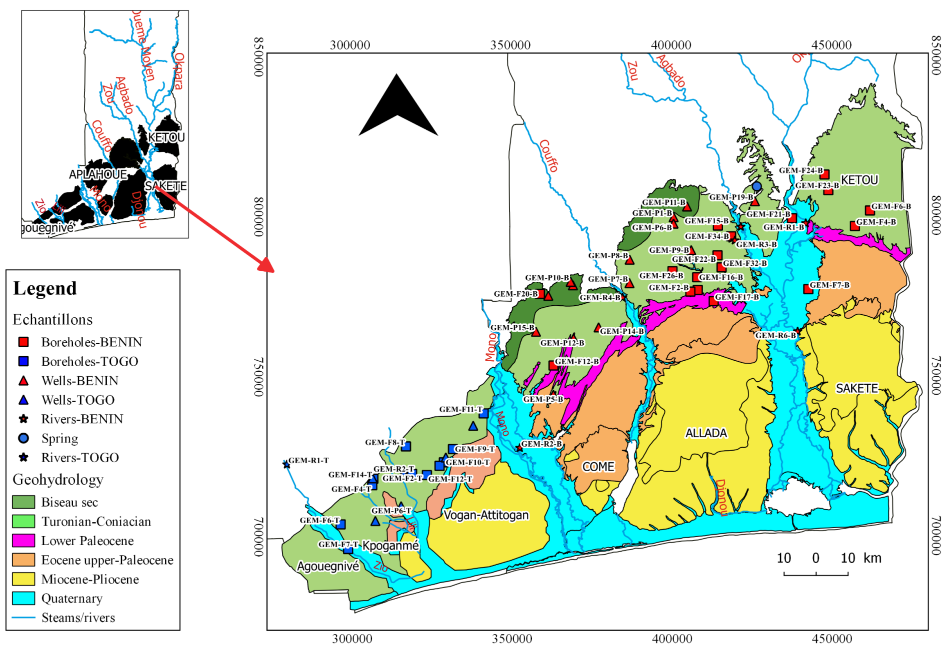


Figure 2. Spatial distribution showing the sampling points for the second campaign July 2023.

3.2. Data Analysis and Processing Methods

3.2.1. Methods

Physicochemical parameters such as electrical conductivity, TDS, and temperature were measured in situ during the field campaigns. Chemical elements such as

Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-}, NO_3^-, and HCO_3^- were analyzed at the Applied Hydrology Laboratory of the University of Abomey-Calavi, Benin, during the first field campaign. Analysis was performed using DIONEX ICS1000 ion chromatography equipped with the IonPac CS12A analytical column for cations, using methanesulfonic acid as the eluent, and the IonPac AS14A-7 µm analytical column for anions. The overall limit of detection for ions was 0.04 mg/L. This same method was used in Senegal for the major element analyses conducted there. In Togo, samples were analyzed by atomic absorption spectrophotometry (thermo-electron spectroscopy) coupled to a VP100 hydride generator. The ionic balance of all samples ranged from −5% to +5%.

The analysis data for the groundwater samples studied for the two seasons are presented in **Table S1** for the dry season and **Table S2** for the rainy season, respectively (Data available in the attached file).

3.2.2. Data Processing

Hydrochemical data were used to determine water types using the Piper diagram generated with Grapher 15. To support the Piper diagram results, a hypothetical salt combination was used to estimate different assemblages. Hierarchical cluster analysis (HCA) was used to examine any similarities in chemical composition between river and groundwater. Cluster analysis has already proven effective in identifying waters with similar and different chemical compositions ([16]-[18], cited in [19]). This approach is based on Ward's coupling method (Ward 1963) with squared Euclidean distances as a measure of similarity between samples [19]-[22]. The R statistical package version 4.3.2 (October 31, 2023) was used for the statistical analyses.

4. Results and Discussions

4.1. Physico-Chemical Parameters

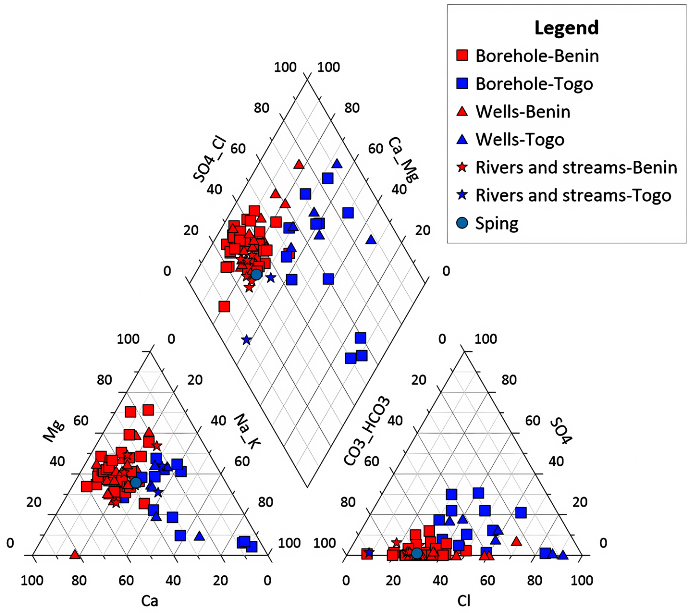
The parameters directly measured on site, namely electrical conductivity (EC), pH, water temperature (T˚C), and major element concentrations measured during the dry and rainy seasons, are recorded in **Table S1** and **Table S2** respectively (available in the attached document). The pH varies between 5.08 and 7.71 throughout the year, with an average value of 6.34, indicating that the deep Turonian-Coniacian groundwater is acidic. Surface water temperature during the dry season varies between 30˚C and 35˚C, with an average of 31.45˚C, while during the rainy season it varies between 28˚C and 35˚C, with an average of 30.35˚C. Groundwater temperature during the dry season ranges from 17˚C to 42˚C, with an average of 30.5˚C (**Table S1**, available in the attached document) while during the rainy season it varies between 28˚C and 41˚C with an average of 30.75˚C. These values are close to the average atmospheric temperature in southern Benin (28˚C) and indicate a thermal equilibrium between groundwater, surface water, and the atmosphere.

In water samples taken during periods of low water (in both Benin and Togo), electrical conductivity varies between 8 and 1770 µS/cm, with an average of 256.19

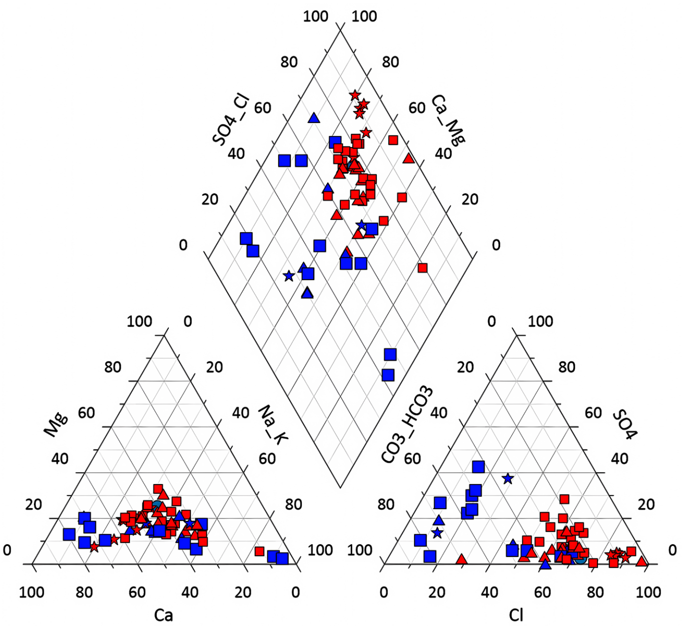
μS/cm. During the rainy season, it varies between 11 and 2740 μS/cm, with an average of 289.82 μS/cm. Electrical conductivity is higher during the rainy season than during the dry season (**Table S1** and **Table S2** in the attached document).

The waters of the Turonian-Coniacian aquifer are found to be weakly mineralized (**Table S1** and **Table S2** in the attached document). This reservoir contains detrital deposits (gravel, sand, sandstone).

4.2. Hydrochemical Types



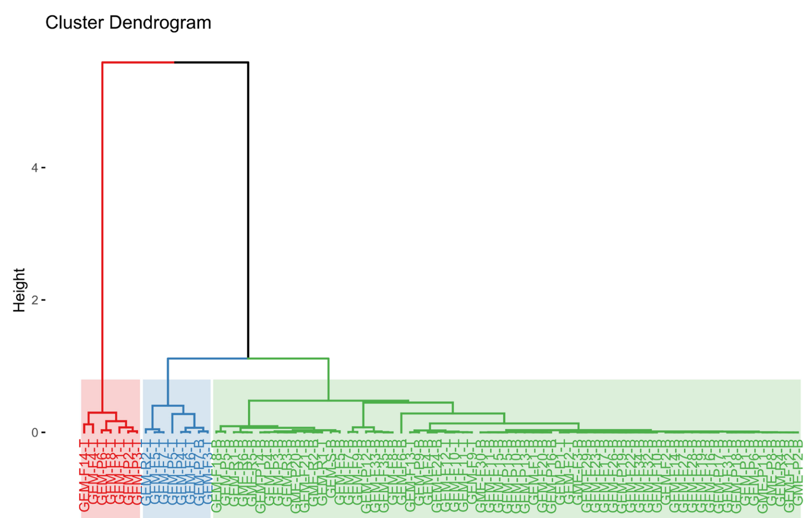
(a)



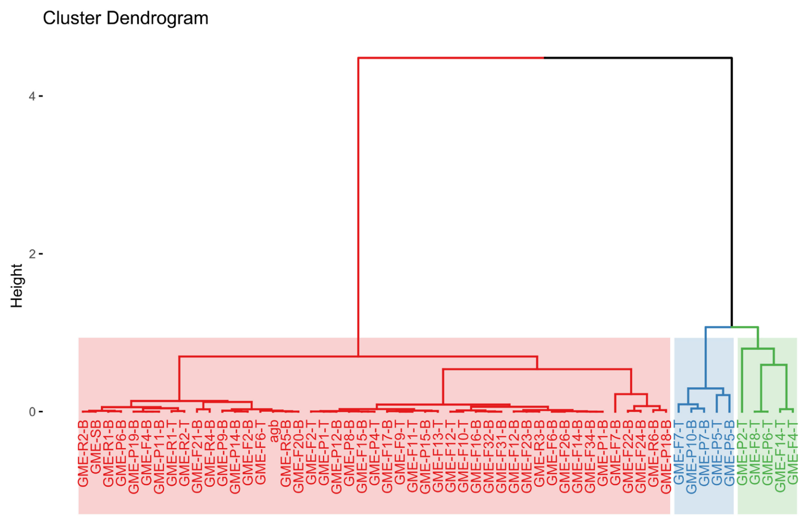
(b)

Figure 3. Diagramm of piper.

Projecting the chemical analysis results onto the Piper diagram clearly shows little variation in water chemistry in both Benin and Togo. In the Benin sedimentary basin, three facies are generally represented, with a predominance of the bicarbonate type (86% $CaHCO_3$ and 8% $MgHCO_3$) during the dry season and the chloride type (66.8% $CaClNO_3$ and 30.8% NaCl) during the rainy season (**Figure 3(a)** and **Figure 3(b)**). In Togo, four facies are represented, with a predominance of the sodium chloride type (61.11%) during the dry season and the bicarbonate type (38.89% $CaHCO_3$ and 27.78%) during the rainy season (**Figure 3(a)** and **Figure 3(b)**). Of the 56 sites where water samples were collected during the dry and rainy seasons, the main hydrochemical characteristics are, in order, $CaCO_3$, $NaKCO_3$, $MgCO_3$, NaKCl, and $CaMgClNO_3$ (dry season) and $CaMgClNO_3$, NaKCl, NaKCl, and $MgClNO_3$ (rainy season). Borehole and river water samples taken in Benin, which exhibit a bicarbonate facies (dry season), shift towards a chloride facies (rainy season). This phenomenon is called dissolution-concentration. 97.41% of the sampled water sources drawing from the Turonian-Coniacian aquifer undergo this process. The opposite effect occurs for water samples taken in Togo. Chloride facies (dry season) change to bicarbonate facies (rainy season), while bicarbonate facies during periods of low water retain their characteristics during the rainy season. We can observe lateral facies variation within the Turonian-Coniacian reservoir extending from Benin to Togo. Thus, the points representing groundwater and surface water are grouped together during the rainy season and similarly during the dry season (**Figure 3(a)** and **Figure 3(b)**). Hydraulic connectivity could be the underlying cause. Furthermore, certain cations, such as calcium, are converted to sodium, and vice versa, as is magnesium, which is converted to sodium or calcium. This demonstrates the phenomenon of cation exchange between the Turonian-Coniacian matrix and the resident water. The Haho River, for its part, transitions from a bicarbonate to a sulfate facies. This is due to water pollution from rice cultivation fertilizers observed in the field during the rainy season, mainly due to excess nitrogen and phosphorus.



(a)



(b)

Figure 4. Dendrogram based on hierarchical grouping (Ward's method) in dry season (a) and rainy season (b).

For the dendrogram, all major elements were used to identify the different phenomena occurring in the reservoir and to study the similarity between surface water and groundwater. The 56 groundwater and surface water samples (considered for the seasonal comparison mentioned above) from both seasons were analyzed separately for the dendrogram. During the dry season, three groups, namely 1, 2, and 3, are observed on the dendrogram (**Figure 4(a)**). Group 1 comprises the groundwater samples with very high electrical conductivities (EC), *i.e.*, EC > 500 μS/cm, and the highest concentrations of Cl, Na, HCO_3, Ca, and NO_3. These are the boreholes GEM-F4-T, GEM-F14-T, GEM-F8-T, GEM-F1-T and the wells GEM-P2-T, GEM-P3-T, GEM-P6-T. These are structures located in urban areas and not well maintained according to our observations on the sites and located totally north of the Fogbé plateau in the outcropping part of the studied aquifer. These varying concentrations of Cl, Na, CE, and especially NO_3 (strictly above 50 mg/L according to WHO, 1993) indicate anthropogenic input, as determined from the Piper diagram. Groups 2 and 3 contain a set of surface and groundwater samples showing similarity in the analyzed parameters (**Figure 4(a)**), with EC below 100 and between 100 and 500 μS/cm. These waters are of the calcium bicarbonate type. Next, three groups are observed based on the rainy season dendrogram (**Figure 4(b)**). However, Group 1 comprises all surface and groundwater samples with the same similarity in analyzed parameters observed in the dry season for Groups 2 and 3, and with the same variation in electrical conductivity observed previously. These waters undergo dissolution, changing from calcium carbonate to calcium chloride and sodium chloride. This indicates an interconnection between surface water and groundwater [7] [17] [19] [23]-[25]. Group 2 comprises water samples with Electrical Conductivities (EC) greater than 500 μS/cm, corresponding to Group 1 of the dry season. Group 3 includes only groundwater samples with very high Electrical Conductivities (EC) (*i.e.*, EC > 500 µS/cm) and the highest concentrations of Cl, Na, HCO_3, Ca, and NO_3, corresponding to Group 1 of the rainy season.

4.3. Correlations between Chemical Elements

The study of binary correlations allowed us to determine the geological and anthropogenic origin of the chemical elements based on the degree of correlation between them. The binary correlations between the parameters support and confirm the principal component analysis (PCA) to explain the acquisition process of each ion.

The dissolution phenomenon observed on the Piper diagram led us to extend our analysis to determine the origin of the transformations of chloride and bicarbonate ions in Benin and Togo, respectively, during the rainy season. Based on the hypothesis that the sudden appearance of chloride ions is linked to the dilution of salt from sea spray, we used physicochemical analysis data from seawater samples used in the doctoral research for the coastal sedimentary basin and the same parameters from rainwater collected at the Bohicon meteorological station (the station covering our study area) to verify the feasibility of this hypothesis (**Figure 5**). All samples showed a chloride concentration lower than that of rainwater. We therefore concluded that the chlorides could not have originated from sea spray, either in Benin or Togo. We then verified the anthropogenic origin using **Figure 6(a)** and **Figure 6(b)**. These graphs illustrate the evolution of chloride concentration as a function of nitrate ion concentration in Benin and Togo, respectively. The majority of samples initially showed a zero nitrate concentration, while chloride concentrations increased. Only seven samples showed a simultaneous increase in both nitrate and chloride concentrations. This is inevitably due to anthropogenic pollution. These samples came from wells GME-P5-T, GME-F14-T, GME-F4-T, and GME-P2-T in Togo, and from traditional wells GME-P9-B, GME-P7-B, and GME-P5-B in Benin. To more precisely identify the source of chlorides in Benin and bicarbonates in Togo during the rainy season, we created **Figure 6(c)** and **Figure 6(d)** after excluding wells with anthropogenic pollution in Benin and Togo, respectively. **Figure 6(c)** illustrates the evolution of chloride concentrations as a function of sodium content. A clustering of samples (groundwater and rivers) is observed along the dissolution line. This confirms the presence of the sodium chloride facies in the reservoir studied in Benin. The Na^+ and Cl^- ions originate from the dissolution of halite. Therefore, a halite source exists in the Turonian-Coniacian reservoir of Benin, where halite dissolved during the rainy season.

Figure 6(d) illustrates the evolution of magnesium and calcium ion concentrations as a function of bicarbonate ion concentration. The grouping of samples (groundwater and rivers) along the dissolution line indicates the presence of carbonate rocks (limestone and dolomite) in the Turonian-Coniacian reservoir, which dissolved during the rainy season. The base exchange phenomenon that occurs in aquifers is illustrated by the relationship $[(Ca^{2+} + Mg^{2+}) - (HCO_3^- + SO_4^{2-})]/[(Na^+ + K^+) - Cl^-]$, as shown in **Figure 6(e)** and **Figure 6(f)**. Subtracting the two parameters $[(Ca^{2+} + Mg^{2+}) - (HCO_3^- + SO_4^{2-})]$ and $[(Na^{2+} + K^+) - Cl^-]$ eliminates ions that may originate from other reactions, such as the dissolution of carbonate minerals and evaporites. In the absence of these base exchange reactions, all sampling points should be located near the origin, in accordance with [26], as is the case for our water samples. The calcium deficit and sodium excess that characterize some sampling points during the rainy season are attributed to ion exchange mechanisms. This process has already been demonstrated in other aquifers [19] [22] [27]. During the rainy season, clays and sandstones can easily exchange their sodium and potassium ions for calcium and magnesium from the water.

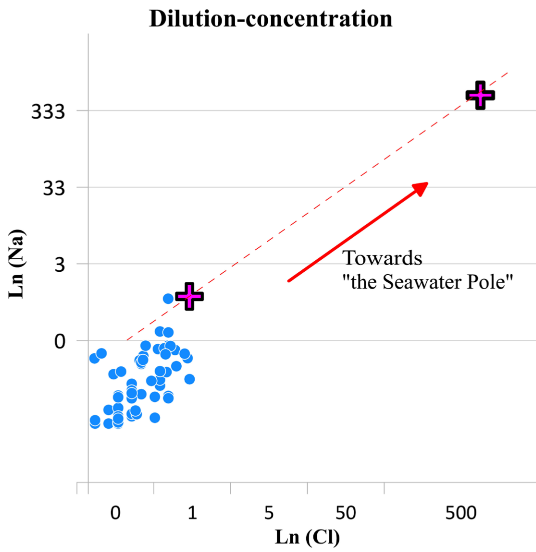


Figure 5. Dilution-concentration graph showing the probable contribution of chlorides from seawater

Three phenomena govern the acquisition of minerals by groundwater. The first is the Dissolution/Concentration phenomenon observed during the rainy season, which transforms all bicarbonate ions into chloride ions in Benin and chloride ions into bicarbonates in the Turonian-Coniacian reservoir. The second mechanism is the impact of human activities. Human waste reaches the deep reservoir through direct infiltration because this aquifer is unconfined in these sampling areas (Dogbo-honto, Zounkpa Centre, Sinwé Gbodjèmè, Have, Kodzo, Ledicopé). The subsequent mechanism of ionic base exchange involves a decrease or elimination of the concentration of certain cations (Ca^{2+}, Mg^{2+}) to make way for new cations (Na^+, K^+). All three of these observed mechanisms occur simultaneously in surface and groundwater, highlighting the interconnectivity between groundwater and surface water.

Hydrochemical types, dendrograms, and ionic combinations allowed us to determine the ionic compositions of the Turonian-Coniacian reservoir, their acquisition processes by the waters, and their interactions with the matrix.

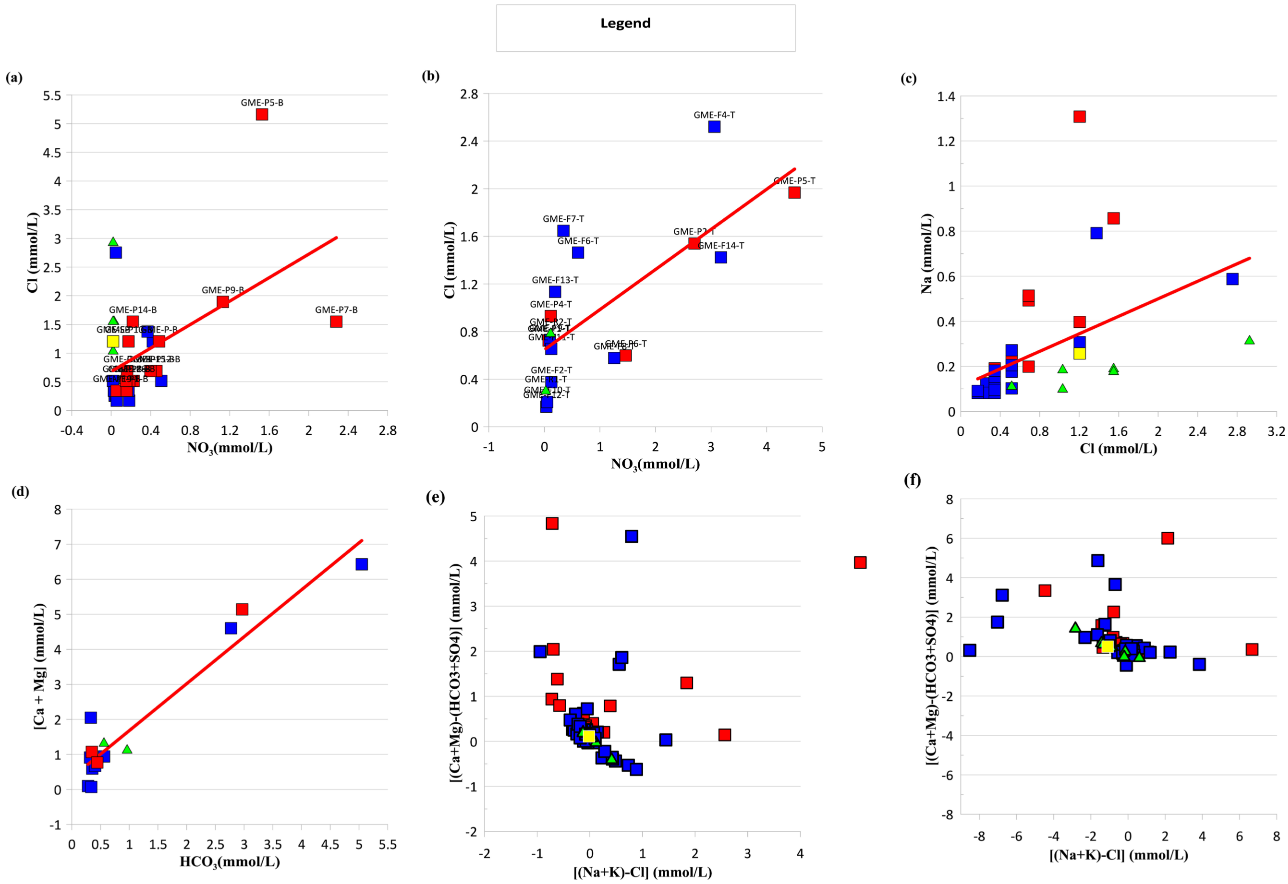


Figure 6. (a)-(f) Correlations between chemical elements.

5. Conclusions

Our study was based on a hydrogeochemical approach to try to provide an understanding of the functioning of the Turonian Coniacian aquifer system captured for exploitation, more easily in the North of the Coastal Sedimentary Basin of Benin-Togo. The aim was to determine the hydrogeochemical type of the reservoir waters, to study the process of water mineralization, and to verify the possible existence of an interconnection between the reservoir and surface waters.

The geochemical parameters analyzed show significant variations over time for both groundwater and surface water. Groundwater and surface water exhibit similar hydrochemical facies during the rainy and dry seasons. The chemical compositions of the analyzed samples were plotted on the Piper diagram [28]. Projecting the results of the chemical analyses onto this diagram clearly shows a low variation in water chemistry, indicating very low mineralization and an average acidic pH. The waters of the Turonian-Coniacian stage exhibit lateral facies variation. In the Benin Sedimentary Basin, they are generally composed of three facies, with a predominance of the bicarbonate type (86% Ca-HCO_3 and 8% Mg-HCO_3) during the dry season and the chloride type (66.8% Ca-Cl-NO_3 and 30.8% Na-Cl) during the rainy season. In Togo, four facies are represented, with a predominance of the sodium chloride type (61.11%) during the dry season and the bicarbonate type

(38.89% Ca-HCO_3 and 27.78%) during the rainy season. The facies changes observed between the dry and rainy seasons allowed us to identify three processes of mineral acquisition by Turonian-Coniacian waters: dissolution/concentration, the impact of human activities, and the base exchange mechanism. The HCA results initially confirm this mineral acquisition process and subsequently demonstrate a probable interconnection between surface and groundwater during the dry and rainy seasons. Combinations of different ions yielded the same results. Our work, through our various findings, confirms the work of our predecessors [5] [7] and can significantly contribute to the efficient management of surface water and the common reservoir waters of the Benin-Togo Coastal Sedimentary Basin. Nevertheless, they warrant further investigation through lithostratigraphy to identify evaporite and carbonate rocks in Benin and Togo. It will also be necessary to determine how the interconnection between Turonian and Coniacian surface waters is occurring. Once obtained, all these results can be confirmed by isotopic analysis.

Acknowledgements

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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Table S1. Physico-chemical analysis data from the first low water campaign.

Sample names	Label	CODE	Nature	Temperature	TDS	EC	pH	meq HCO_3	meq SO_4	meq Cl	meq NO_3	meq Cl + NO_3	meq Ca	meq Mg	meq K	meq Na	meq Na + K	Cations	Anions	Ionic balance
DEKANDJI BOHOUNGOHOUE	FA	GEM-F12-B	Borehole	29.8	4	0	6.2	0.85	0.02	0.29	0.12	0.41	0.51	0.53	0.06	0.3	0.36	1.41	1.28	4.9
AYEKOU ARAROMI	F	GEM-F23-B	Borehole	30	15	30	5.83	0.87	0	0.29	0	0.29	0.59	0.37	0	0.1	0.1	1.05	1.16	−4.87
OGBOLOUWA	F	GEM-F6-B	Borehole	17	28	34	5.81	0.67	0	0.28	0.05	0.33	0.52	0.54	0.01	0.05	0.06	1.11	1	4.92
DOKPA HLAVLAMEHOHE	F	GEM-F14-B	Borehole	31	17	34	5.98	0.47	0	0.24	0	0.24	0.39	0.32	0.01	0.06	0.07	0.79	0.71	4.95
IGBO EWE	F	GEM-F4-B	Borehole	28.4	18	36	5.66	0.66	0	0.22	0	0.22	0.57	0.32	0.01	0.05	0.06	0.95	0.88	4.11
HLAGBA-ZAKPO	F	GEM-F17-B	Borehole	30.3	18	37	6	0.67	0.03	0.34	0.06	0.4	0.52	0.43	0.05	0.19	0.24	1.19	1.11	3.67
AWODOKPODJI	Puits	GEM-P19-B	Well	30	21	42	5.98	0.8	0	0.36	0.01	0.38	0.64	0.57	0.02	0.04	0.06	1.28	1.17	4.35
HLAFANDJI	F	GEM-F34-B	Borehole	30	21	42	5.96	0.81	0	0.32	0.02	0.35	0.54	0.43	0	0.08	0.08	1.05	1.15	−4.81
Davou	F	GEM-F12-T	Borehole		73.3	43.8	5.37	0.28	0.21	0.17	0.04	0.21	0.05	0.04	0.02	0.58	0.6	0.7	0.7	0.04
GLANDJANGON	F	GEM-F29-B	Borehole	30	22	44	6.07	1.11	0	0.48	0	0.48	0.39	1.19	0.02	0.09	0.11	1.69	1.59	3.1
SAMIONTA FORAGE	FA	GEM-F32-B	Borehole	30	22	44	6.01	0.91	0.01	0.2	0.02	0.22	0.39	0.53	0.01	0.12	0.13	1.06	1.15	−3.97
AYIHOUGON	F	GEM-F27-B	Borehole	31	23	44	5.98	0.62	0	0.38	0.03	0.41	0.5	0.37	0.01	0.08	0.08	0.95	1.03	−4.26
AGONGBO	F	GEM-F26-B	Borehole	30	24	48	6	0.93	0	0.32	0.05	0.37	0.54	0.37	0.06	0.22	0.28	1.19	1.31	−4.91
HLAHONOU FA	FA	GEM-F16-B	Borehole	31	25	48	6.09	0.5	0.01	0.32	0.04	0.36	0.31	0.43	0.02	0.13	0.15	0.9	0.88	1.24
KOTOKPA	F	GEM-F19-B	Borehole	31	25	48	6.29	0.5	0.05	0.34	0.03	0.36	0.44	0.47	0.01	0.09	0.1	1	0.92	4.13
HEHOUNU	F	GEM-F10-B	Borehole	30	27	54	6	0.7	0	0.32	0.02	0.34	0.55	0.41	0.03	0.13	0.16	1.12	1.04	3.64
EDOUAGNON	F	GEM-F24-B	Borehole	29	28	56	5.6	0.78	0	0.46	0.03	0.49	0.58	0.37	0.01	0.22	0.22	1.17	1.27	−4.27
SAGON ILLAKA	F	GEM-F33-B	Borehole	33	28	58	5.78	0.5	0	0.26	0	0.26	0.32	0.29	0.01	0.09	0.09	0.7	0.76	−4.34
KPOHOUEGBEGON	F	GEM-F22-B	Borehole	30	30	60	5.95	0.9	0	0.44	0.03	0.47	0.64	0.53	0.02	0.1	0.11	1.28	1.37	−3.38
DJAYIDOSSOU	F	GEM-F35-B	Borehole	35	32	62	5.8	0.71	0	0.24	0	0.24	0.43	0.36	0	0.08	0.08	0.87	0.95	−4.56
RIVIERE ZAGBO	River	GEM-R3-B	River	30	32	64	6.72	0.72	0.01	0.24	0	0.24	0.54	0.27	0.04	0.2	0.23	1.04	0.98	2.77
ZOUKOU ALIKPA	F	GEM-F31-B	Borehole	30	32	64	6.08	0.58	0	0.19	0.11	0.29	0.14	0.68	0.02	0.11	0.13	0.95	0.88	4.13
TINDJI-HELOU KPEDJO	Puits	GEM-P1-B	Well	30	32	64	6.21	0.5	0	0.28	0	0.28	0.45	0.26	0.02	0.13	0.15	0.86	0.78	4.74
Lobokondji	F	GEM-F11-T	Borehole		111.5	65.6	5.63	0.29	0.04	0.13	0.06	0.19	0.09	0.22	0.02	0.2	0.23	0.53	0.53	0.09
AKANTE-ZOUNGO	F	GEM-F8-B	Borehole	35	31	66	5.86	0.69	0.14	0.34	0	0.34	0.61	0.54	0.01	0.13	0.13	1.28	1.17	4.42
Kpessécopé	**F**	**GEM-F10-T**	Borehole		110.7	66.6	5.23	0.34	0.17	0.21	0.05	0.26	0.04	0.03	0.02	0.68	0.7	0.77	0.77	0.04
OUNHI WOKON AYIHOUEDJI	FA	GEM-F9-B	Borehole	39.2	35	68	6	0.75	0.06	0.3	0	0.3	0.54	0.5	0.01	0.11	0.13	1.17	1.11	2.38
Houingbesso	**F**	**GEM-F9-T**	Borehole		120	70.6	5.6	0.64	0.06	0.38	0.2	0.58	0.08	0.09	0.02	1.09	1.11	1.28	1.28	0.04
AGRIMEY-KABOHOUE	F	GEM-F11-B	Borehole	29	41	82	6.08	0.85	0	0.26	0.07	0.34	0.49	0.53	0.05	0.22	0.28	1.3	1.19	4.62
OUINHI-ZOUNGUE	FA	GEM-F7-B	Borehole	42	41	84	5.86	0.71	0.03	0.24	0	0.24	0.45	0.49	0.03	0.09	0.11	1.06	0.98	3.75
Zio GAPEKPEDZI	**River**	**GEM-R1-T**	**River**		150.6	90	7.14	1.27	0.02	0.12	0	0.12	0.44	0.43	0.06	0.48	0.54	1.41	1.41	0.07
AGRIMEY KPASSASSA	F	GEM-F2-B	Borehole	31	45	91	6	0.74	0.08	0.36	0.03	0.39	0.55	0.47	0.04	0.21	0.25	1.27	1.21	2.29
EPP GBONOU	F	GEM-F1-B	Borehole	29	45	92	6.37	0.66	0.04	0.38	0.01	0.39	0.5	0.39	0.03	0.25	0.27	1.17	1.08	3.71
TINDJI ZOUGOUDO	Well	GEM-P6-B	Well	30	46	92	6.17	0.6	0.02	0.28	0.07	0.35	0.56	0.33	0.03	0.15	0.18	1.07	0.97	4.94
ADJIDO	Well	GEM-P17-B	Well	31	46	94	6.15	0.6	0.02	0.24	0.11	0.35	0.54	0.39	0.01	0.13	0.14	1.07	0.97	4.87
AIDJEDO KPOTO F2	F	GEM-F28-B	Borehole	32	50	100	6.16	1.07	0	0.26	0	0.26	0.36	0.72	0.01	0.13	0.14	1.21	1.33	−4.57
FLEUVE OUEME AHLAN	River	GEM-R1-B	Fleuve	33	52	102	6.71	0.82	0.02	0.28	0	0.28	0.25	0.66	0.05	0.27	0.32	1.22	1.12	4.4
AGBOZOUNDJI	Well	GME-P20-B	Well	30	56	110	6.53	0.77	0	0.26	0.04	0.3	0.54	0.43	0.02	0.17	0.19	1.16	1.07	4
Akoudokpo	Well	**GEM-P1-T**	Well		185	110	5.97	0.45	0.1	0.72	0.08	0.8	0.51	0.26	0.03	0.56	0.58	1.35	1.35	0.08

Continued

DAKOHOUE	Well	GEM-P18-B	Well	30.2	57	112	6.1	0.6	0	0.28	0.07	0.35	0.18	0.54	0.02	0.15	0.17	0.89	0.96	−4.02
GBOLI MIGNON HITO	Well	GME-P8-B	Well	30	58	118	6.3	0.99	0	0.36	0.09	0.45	0.57	0.54	0.02	0.17	0.19	1.3	1.43	−4.84
TANKPA TANKPA	Well	GME-P11-B	Well	30	60	122	6.27	0.91	0	0.28	0.05	0.33	0.5	0.5	0.03	0.18	0.21	1.21	1.24	−1.1
N'SSOUGANHOUE	F	GME-F3-B	Borehole	29.7	125	125	5.98	0.89	0	0.38	0.03	0.41	0.53	0.49	0.08	0.28	0.35	1.37	1.3	2.7
Kougnrowou copé	**F**	**GEM-F13-T**	Borehole	30.775	208	127	5.23	0.33	0.02	1.12	0.67	1.79	0.67	0.4	0.03	1.04	1.07	2.14	2.14	0.04
Anagali	**F**	**GEM-F2-T**	Borehole		224	131	6.03	0.49	0.35	0.75	0.02	0.77	0.61	0.36	0.05	0.6	0.65	1.62	1.62	0.03
FLEUVE MONO ATIEME	River	GME-R2-B	Fleuve	31.8	77	136	7.07	0.84	0.07	0.2	0	0.2	0.47	0.41	0.09	0.22	0.32	1.19	1.11	3.77
LAGBAKADA-MAKUI	Puits	GME-P2-B	Well	29.8	69	138	6.2	0.8	0	0.26	0.06	0.32	0.52	0.43	0.06	0.22	0.29	1.23	1.13	4.44
FLEUVE OUEME A AYOGO	River	GME-R6-B	River	35	72	146	6.98	0.87	0	0.37	0	0.37	0.53	0.52	0.03	0.22	0.24	1.29	1.24	2.04
KPODJI ZOUDJAME	F	GME-F30-B	Borehole	28.2	75	150	6.08	0.71	0	0.38	0.11	0.49	0.54	0.43	0.05	0.26	0.32	1.28	1.2	3.44
Tonakondji	Well	**GEM-P4-T**	Well		265	160	6	0.46	0.04	2.12	1.17	3.29	0.92	0.37	0.03	2.48	2.51	3.8	3.79	0.02
FLEUVE ZOU	River	GME-R5-B	River	33.6	82	162	7.02	1.01	0.02	0.36	0	0.36	0.51	0.72	0.05	0.19	0.23	1.47	1.39	2.59
GBOZOUME SOURCE BANAME	Source	GEM-S-B	Source	26	84	164	6.66	0.87	0.01	0.37	0	0.37	0.51	0.48	0.07	0.28	0.35	1.35	1.25	3.71
CENTRE DE SANTE HOUETAN	F	GEM-F20-B	Borehole	29	93	168	6.28	0.58	0.04	0.3	0.23	0.53	0.51	0.32	0.05	0.39	0.45	1.27	1.16	4.86
SOKEHOU SOKEHOUE PUITS	Well	GEM-P12-B	Well	36.2	84	168	6.22	1.19	0	0.36	0.14	0.5	0.57	0.68	0.05	0.22	0.27	1.53	1.69	−4.99
BABOHOUE PUITS	Well	GEM-P15-B	Well	29	88	174	6.11	0.81	0	0.38	0.21	0.59	0.76	0.39	0.05	0.25	0.3	1.45	1.39	2.1
LEGBAHOLI MIGNANHOUNGON	Well	GEM-P13-B	Well	30	99	192	6.3	0.91	0	0.38	0.42	0.79	0.48	1.06	0.05	0.21	0.26	1.79	1.7	2.64
KPOTO AIDJEDO voie	F	GEM-F21-B	Borehole	31	96	192	6.76	1.97	0.01	0.18	0	0.18	0.79	0.82	0.05	0.36	0.41	2.03	2.17	−3.25
USP Assomé	**F**	**GEM-F6-T**	Borehole		357	205	5.96	1.75	0.06	1.09	1.47	2.56	1.42	0.42	0.03	2.5	2.53	4.37	4.36	0.06
FLEUVE COUFFO	River	GEM-R4-B	River	30	106	212		0.81	0.06	0.34	0.01	0.35	0.58	0.45	0.07	0.19	0.25	1.28	1.22	2.57
LOKOSSOUHOUE PUITS	Well	GEM-P16-B	Well	29	106	214	6.19	0.89	0	0.34	0.3	0.63	0.58	0.71	0.07	0.33	0.39	1.68	1.52	4.93
LAINTA ADJA HOUEKO	F	GEM-F15-B	Borehole	29	106	214	6.11	0.8	0.01	0.32	0.14	0.46	0.51	0.51	0.07	0.3	0.38	1.39	1.28	4.18
ZOUNKPA CENTRE PUITS	Well	GEM-P9-B	Well	30	128	250	5.23	0.96	0	1.04	0.42	1.47	1.11	0.65	0.1	0.37	0.47	2.22	2.42	−4.37
KPODJI CENTREPUITS	Well	GEM-P3-B	Well	30.8	129	258	6.58	0.8	0.01	0.39	0	0.39	0.55	0.43	0.08	0.22	0.3	1.27	1.19	3.34
KEMODJI YAGBE	Well	GEM-P14-B	Well	30	132	264	6.87	0.7	0	0.34	0.1	0.44	0.54	0.48	0.06	0.18	0.24	1.26	1.15	4.58
TOHOUEHOUE	Well	GEM-P4-B	Well	29	140	286	6.74	0.84	0.03	0.28	0.13	0.41	0.51	0.51	0.08	0.27	0.35	1.37	1.28	3.53
Fleuve HAHO à Gati	**River**	**GEM-R2-T**	Borehole		559	326	7.66	3.78	0.1	1.86	0.16	2.02	1.37	2.58	0.43	1.53	1.96	5.91	5.9	0.03
Kpédévi kopé (musulman don)	**F**	**GEM-F3-T**	Borehole		568	333	6.24	2.76	0.92	1.55	0.06	1.61	1.22	2.23	0.04	1.79	1.84	5.29	5.29	0.02
ISSABA GBAGUI	F	GEM-F5-B	Borehole	28.4	186	376	7.34	0.82	0.13	0.22	0.08	0.3	0.4	0.66	0.08	0.22	0.29	1.35	1.25	4.12
SINWE GBODJEME	Well	GEM-P7-B	Well	30	195	390	6.18	3.48	0	0.52	0.7	1.22	3.64	0.04	0.15	0.64	0.79	4.47	4.7	−2.51
GNONGBE PUITS	Well	GEM-P10-B	Well	29.2	204	408	6.08	0.75	0	1	0.06	1.06	0.76	0.93	0.06	0.22	0.28	1.97	1.82	4.06
Yobo	Well	**GEM-P6-T**	Well		652	421	6.61	2.65	1.13	3.88	1.35	5.23	1.89	3.93	1.16	2.03	3.19	9.01	9.01	0.02
Kpédévi kopé (DGEA)	**F**	**GEM-F7-T**	Borehole		850	503	7.11	5.54	0.21	1.99	0.07	2.06	3.69	2.22	0.37	1.53	1.91	7.82	7.81	0.05
Essè Zogbedji	**F**	**GEM-F1-T**	Borehole		1320	744	6.74	4.77	1.1	2.49	2.46	4.95	2.57	5.17	0.05	3.04	3.1	10.83	10.83	0.03
Essé Nadjè	**F**	**GEM-F8-T**	Borehole		1292	780	6.57	3.22	1.25	3.4	2.26	5.67	1.65	4.53	0.71	3.25	3.96	10.14	10.14	0.02
DOGBO-HONTO	Well	GEM-P5-B	Well	29.8	460	940	6.83	0.6	0.18	1.06	0.65	1.71	1.25	0.92	0.11	0.33	0.44	2.61	2.5	2.26
Lédicopé	Well	**GEM-P5-T**	Well		1403	940	4.87	0.65	0.04	3.43	4.12	7.54	2.68	2.85	0.07	2.65	2.71	8.24	8.24	0.03
Havé puits 2	Well	**GEM-P3-T**	Well		2060	1310	6.96	5.24	2.25	1.9	3.13	5.04	3.23	5.56	0.89	2.86	3.74	12.53	12.53	0.02
Havé	**F**	**GEM-F14-T**	Borehole		2010	1330	6.34	2.3	3.13	4.08	5.34	9.41	4.26	5.71	0.96	3.91	4.87	14.84	14.83	0.03
TOCHIKEMEY	F	GEM-F18-B	Borehole	28	712	1424	7.22	0.81	0.04	0.67	0.16	0.83	0.42	1.03	0.12	0.28	0.4	1.85	1.67	4.93
Kodzo	**F**	**GEM-F4-T**	Borehole		2710	1720	6.5	4.22	4.5	4.97	1.04	6.01	5.07	5.64	0.71	3.32	4.03	14.74	14.73	0.03
Havé puits	Well	**GEM-P2-T**	Well		2740	1770	6.94	5.78	2.04	1.54	2.7	4.24	3.88	4.08	0.6	3.5	4.11	12.07	12.06	0.03

Table S2. Physico-chemical analysis data from the second campaign, July 2023.

Sample names	Nature	CODE	Temperature	TDS	EC	pH	meq HCO_3	meq SO_4	meq Cl	meq NO_3	meq Cl + NO_3	meq Ca	meq Mg	meq K	meq Na	meq Na + K	Cations	Anions	ionic balance
FLEUVE OUEME AHLAN	River	GME-R1-B	28.4	35	11	6.83	0.06	0.04	1.03	0.02	1.05	0.5	0.09	0.01	0.1	0.11	0.7	1.15	−24.55
OGBOOLUWA	Borehole	GME-F6-B	29.9	12	23	5.58	0.06	0.02	0.26	0.04	0.29	0.08	0.06	0.01	0.12	0.13	0.27	0.37	−16.13
ARAROMI	Borehole	GME-F23-B	29.3	13	27	6.08	0.06	0.03	0.26	0.05	0.31	0.08	0.12	0.01	0.08	0.09	0.29	0.4	−16.07
DOKPA HLAVLAMEHOUE	Borehole	GME-F14-B	30.4	15	30	6.01	0.07	0.02	0.17	0.06	0.23	0.11	0.09	0.01	0.08	0.09	0.29	0.32	−4.8
SAMIONTA	Borehole	GME-F32-B	31	17	34	5.4	0.07	0.03	0.34	0.07	0.42	0.21	0.12	0.01	0.08	0.09	0.42	0.52	−10.39
HLA FANDJI	Borehole	GME-F34-B	30.5	17	35	5.8	0.07	0.03	0.34	0.06	0.4	0.11	0.13	0.01	0.13	0.14	0.38	0.5	−13.57
AWOLOKPODJI	Well	GME-P19-B	30.3	18	37	6.72	0.09	0.03	0.34	0.05	0.4	0.18	0.13	0.01	0.09	0.09	0.4	0.52	−12.43
EGBO EWE	Borehole	GME-F4-B	29.7	19	38	6.63	0.07	0.13	0.34	0.03	0.37	0.2	0.13	0.01	0.1	0.11	0.45	0.57	−12.48
AGONGBO	Borehole	GME-F26-B	30	20	40	5.57	0.08	0.02	0.34	0.14	0.48	0.27	0.08	0.01	0.1	0.11	0.46	0.59	−12.63
OUINHI-ZOUNGUE	Borehole	GME-F7-B	41	25	41	7.15	0.08	0.09	0.52	0.02	0.54	0.16	0.24	0.01	0.1	0.11	0.51	0.71	−16.82
HLAHONOU	Borehole	GME-F16-B	31	21	42	5.08	0.08	0.03	0.17	0.18	0.35	0.19	0.13	0.01	0.09	0.1	0.42	0.47	−5.11
ZAGBO	River	GME-R3-B	28.6	23	46	6.19	0.1	0.03	0.52	0.04	0.56	0.2	0.19	0.01	0.11	0.12	0.5	0.68	−15.13
KPOHOUEGBEGON	Borehole	GME-F22-B	36	23	47	5.14	0.09	0.03	0.34	0.14	0.48	0.2	0.18	0.01	0.1	0.11	0.49	0.6	−10.08
TINDJI HELOU KPEDJO	Well	GME-P1-B	30.4	25	50	5.82	0.08	0.03	0.34	0.16	0.5	0.22	0.13	0.01	0.19	0.2	0.55	0.61	−5.23
EDOUAGNON (K.Ville)	Borehole	GME-F24-B	34	25	50	5.44	0.06	0.06	0.34	0.17	0.51	0.22	0.11	0.01	0.18	0.19	0.52	0.63	−10.02
ZOUKOU ALIKPA	Borehole	GME-F31-B	30.6	24	51	5.43	0.09	0.05	0.34	0.18	0.52	0.28	0.17	0.01	0.1	0.1	0.55	0.66	−8.97
Houingbesso	Borehole	GME-F9-T		42.6	65.5	5.7	0.36	0.06	0.73	0.1	0.83	0.45	0.14	0.03	0.63	0.65	1.25	1.25	0
TINDJI ZOUNGOUDO	Well	GME-P6-B	29.4	33	66	7.19	0.11	0.04	0.52	0.23	0.74	0.27	0.25	0.01	0.18	0.19	0.71	0.9	−11.82
HLAGBA-ZAKPO	Borehole	GME-F17-B	31.5	33	66	5.87	0.12	0.13	0.52	0.2	0.71	0.29	0.23	0.02	0.27	0.29	0.81	0.96	−8.75
GBOLI-MIGNONHITO	Well	GME-P8-B	31.6	35	71	6.29	0.14	0.03	0.52	0.18	0.7	0.26	0.21	0.02	0.22	0.24	0.71	0.88	−10.35
LoBokondji	Borehole	GME-F11-T		46.6	71.1	5.78	0.41	0.06	0.65	0.13	0.78	0.48	0.19	0.03	0.55	0.58	1.25	1.25	0.04
Zio à GAPEKPEDZI	River	GME-R1-T		47	72.3	7.07	0.96	0.23	0.3	0.03	0.33	0.69	0.43	0.04	0.36	0.4	1.52	1.52	0.04
Davou	Borehole	GME-F12-T		43.8	73.3	5.37	0.28	0.21	0.17	0.04	0.21	0.05	0.04	0.02	0.58	0.6	0.7	0.7	0.04
TANKPA	Puits	GME-P11-B	30	37	75	6.63	0.12	0.09	0.52	0.15	0.67	0.28	0.2	0.02	0.2	0.23	0.7	0.88	−10.98
DAKOHOUE	Puits	GME-P18-B	32.4	38	76	6.71	0.14	0.03	0.69	0.16	0.85	0.35	0.22	0.02	0.2	0.21	0.79	1.02	−12.87
DEKANDJI	Borehole	GME-F12-B	29.5	90	90	5.98	0.16	0.11	0.52	0.21	0.73	0.42	0.28	0.01	0.18	0.19	0.88	1	−6.07
LAINTA ADJA HOUEKO	Borehole	GME-F15-B	31	45	91	6.31	0.14	0.04	0.52	0.51	1.02	0.38	0.37	0.02	0.21	0.22	0.98	1.21	−10.4
HAHO à Gati	River	GME-R2-T		60.2	91.8	7.1	0.56	0.77	0.78	0.11	0.9	0.68	0.64	0.06	0.85	0.91	2.23	2.23	0
FLEUVE ZOU	River	GME-R5-B	29.5	50	100	6.11	0.12	0.05	1.55	0.03	1.58	0.61	0.17	0.01	0.19	0.2	0.98	1.74	−27.95
TCHIDEHOU SOKEHOUE	Puits	GME-P12-B	31	52	105	6.23	0.26	0.03	0.69	0.46	1.15	0.41	0.35	0.04	0.49	0.53	1.29	1.43	−5.06
FLEUVE MONO	River	GME-R2-B	28.6	109	109	7.11	0.1	0.06	1.55	0.02	1.57	0.54	0.31	0.02	0.18	0.19	1.04	1.74	−24.96
Kpessécopé	Borehole	GME-F10-T	30.98	66.6	110.7	5.23	0.34	0.17	0.21	0.05	0.26	0.04	0.03	0.02	0.68	0.7	0.77	0.77	0.04
Anagali	Borehole	GME-F2-T		76.3	118.3	6.12	0.56	0.31	0.38	0.13	0.5	0.63	0.32	0.04	0.39	0.43	1.38	1.38	0.01
S. GBATEZOUME	Spring	GME-SB	28	56	120	7.19	0.24	0.03	1.2	0.02	1.22	0.38	0.39	0.02	0.26	0.27	1.05	1.49	−17.53
BABOHOUE	Well	GME-P15-B	29.4	70	140	5.62	0.36	0.03	0.69	0.4	1.09	0.47	0.33	0.05	0.51	0.57	1.37	1.48	−3.85
CS HOUETAN	Borehole	GME-F20-B	29.4	70	140	6.2	0.21	0.06	1.2	0.42	1.63	0.55	0.53	0.02	0.31	0.33	1.41	1.89	−14.69
Kougnonrou copé	Borehole	GME-F13-T		96.3	144.7	5.45	0.32	0.04	1.13	0.19	1.33	0.44	0.47	0.01	0.77	0.78	1.69	1.69	0
FLEUVE OUEME AYOGO	River	GME-R6-B	35	72	146	6.11	0.09	0.04	1.03	0.02	1.05	0.39	0.18	0.02	0.18	0.2	0.78	1.18	−20.55
KEMONDJI YAGBE	Well	GME-P14-B	29.6	84	169	6.31	0.5	0.13	1.55	0.22	1.77	0.66	0.44	0.07	0.86	0.93	2.02	2.4	−8.48
FLEUVE COUFFO	River	GME-R4-B	29	86	172	7.57	0.14	0.07	2.93	0.02	2.95	1.03	0.59	0.05	0.31	0.37	1.99	3.15	−22.63

Continued

Tonakondji	Well	GME-P4-T		117	173.5	6.27	0.35	0	0.93	0.12	1.05	0.73	0.34	0.03	0.3	0.32	1.4	1.4	0.07
USP Assomé	Borehole	GME-F6-T		115	176.4	6	0.33	0.08	1.46	0.61	2.07	1.64	0.41	0.05	0.39	0.44	2.49	2.49	0.06
KPOTO AIDJEDO	Borehole	GME-F21-B	31.5	91	182	6.76	0.07	0.12	2.75	0.05	2.8	0.67	0.49	0.04	0.59	0.63	1.79	2.99	−25.09
Akoudokpo	Well	GME-P1-T		110	185	5.97	0.45	0.1	0.72	0.08	0.8	0.51	0.26	0.03	0.56	0.58	1.35	1.35	0.08
AGRIMEY KPASSASSA	Borehole	GME-F2-B	30	106	212	6.18	0.46	0.42	1.38	0.37	1.75	0.9	0.53	0.06	0.79	0.85	2.29	2.63	−6.88
LOKOSSOUHOUE	Well	GME-P-B	29	106	214	6.58	0.34	0.05	1.2	0.48	1.69	0.8	0.56	0.03	0.4	0.43	1.79	2.07	−7.45
ZOUNKPA CENTRE	Well	GME-P9-B	30.3	145	291	6.48	0.36	0.15	1.89	1.13	3.02	1	1.08	0.05	0.75	0.8	2.88	3.53	−10.04
GNONGBE	Well	GME-P10-B	31.2	168	336	6.59	1.74	0.08	1.2	0.17	1.38	1.44	1.06	0.08	1.31	1.39	3.88	3.2	9.59
SINWE GBODJEME	Well	GME-P7-B	32	185	371	6.04	0.71	0.11	1.55	2.28	3.83	1.82	1.27	0.09	1.27	1.36	4.44	4.65	−2.28
Kpédévi copé (DGEA)	Borehole	GME-F7-T		303	449	7.2	5.05	0.27	1.65	0.34	1.99	5.34	1.09	0.05	0.85	0.9	7.32	7.31	0.07
DOGBO HONTO	Well	GME-P5-B	29.5	698	698	6.35	1.17	0.89	5.16	1.53	6.69	2.22	3.18	0.1	1.72	1.82	7.23	8.75	−9.53
Yobo	Well	GME-P6-T		525	758	6.8	2.97	1.52	0.6	1.46	2.06	3.38	1.76	1.31	0.11	1.42	6.56	6.55	0.08
Essé Nadjè	Borehole	GME-F8-T		527	781	6.72	2.77	1.44	0.58	1.26	1.84	2.98	1.62	1.34	0.12	1.46	6.06	6.05	0.08
Lédicopé	Well	GME-P5-T		727	1055	5.36	0.48	0.04	1.97	4.5	6.47	4.36	2.16	0.02	0.46	0.48	7	6.99	0.06
Havé	Borehole	GME-F14-T		937	1340	6.42	2.53	3.17	1.42	3.18	4.6	6.79	2.55	0.29	0.66	0.95	10.3	10.29	0.03
Kodzo	Borehole	GME-F4-T		1.01	1445	6.71	3.94	3.25	2.52	3.06	5.58	9.48	2.58	0.06	0.67	0.73	12.79	12.77	0.07
Havé puits	Well	GME-P2-T		1770	2740	6.94	5.78	2.04	1.54	2.7	4.24	3.88	4.08	0.6	3.5	4.11	12.07	12.06	0.03