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RESEARCH PAPER OPEN ACCESS

Seasonal variability of the quality of water sources and drilling artesian common Zagnanado and Zogbodomey in central Benin .

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Keywords: artesian water sources; water artesian wells; hydrochemistry; Zagnanado-Zogbodomey region

Abstract

The basins of rivers Ouémé and Zou were selected to better understand the relationships between the waters of artesian springs and artesian water wells in the region Zagnanado and Zogbodomey. From physicochemical analyzes (temperature, pH, electrical conductivity, major cations and anions) on water samples taken from both the artesian springs and artesian wells, the chemical signature of each water system been established. The results show that drilling water has a relatively acidic pH. Against by the sources have a pH close to neutrality. Of the rainy season to the dry season, is observed dynamics of geochemical facies in the waters of artesian wells, while it remains unchanged for almost all water artesian springs. . The waters of artesian springs have a chemical signature similar to that of artesian wells with an overlay that varies according to climatic events and fracturing phenomena, which allow the rapid transport of water through the bedrock. This reflects the existence of favorable conditions to trade flows between the river system and the continuous aquifers.

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I.INTRODUCTION

In both municipalities, the average rate of access to the water distribution network (SONEB) barely reaches 40% (BIA 2012). Groundwater is the main source of drinking water for people not connected to the drinking water network (WETHE et al., 2003). However, comprehensive hydrochemical characteristics are unknown. Hence the need for more research on the quality and functioning of the most stressed water resources today. This study aims to improve knowledge on water sources and drilling artesian most exploited in the middle of study. From physicochemical analyzes (temperature, pH, electrical conductivity, major cations and anions) on water samples, the chemical signature of each water system was established. As part of the study consists of Commons Zagnanado and Zogbodomey in Benin is between 6 ° 56 'and 7 ° 30' North latitude and 2 ° 05 'and 2 25'de East longitude and covers an area of 1575 km² [Figure 1]. The presence of low topographic areas (valleys, depressions) and the captive nature of the aquifer Turonian-Coniacian and Eo-Paleocene promote groundwater seepage at several points in the two municipalities. Artesian springs and development artesian wells thus created an important source of supply for the populations of the two towns. The relief of the town Zogbodomey is characterized by a plain and a plateau that covers 3/5 of the area of the town, with an elevation of about 137 m between the highest point in the northern part of the town and the lowest point on the south-eastern tip (BIA 2012). This tray is located north of the depression of the Lama whose average altitude is 50 m and width ranging from 5 km west 25 km to the east. Thus, the slopes are generally there less than 5%. The relief of the town Zagnanado is characterized by plains and plateaus causing an elevation of about 270 m between the highest point in the northern part of the town and the lowest point in the southern tip. The slopes are generally there for less than 5%, but nearly 4% of the area is characterized by slopes with a gradient greater than 15% (SDAC, 2012). The rainfall in the two municipalities of sub-equatorial. The analysis of rainfall and temperature in Bohicon station and Zagnanado (1980-2012) reveals that the monthly averages are respectively 1132.9 mm and 1064 mm and 28 ° C.

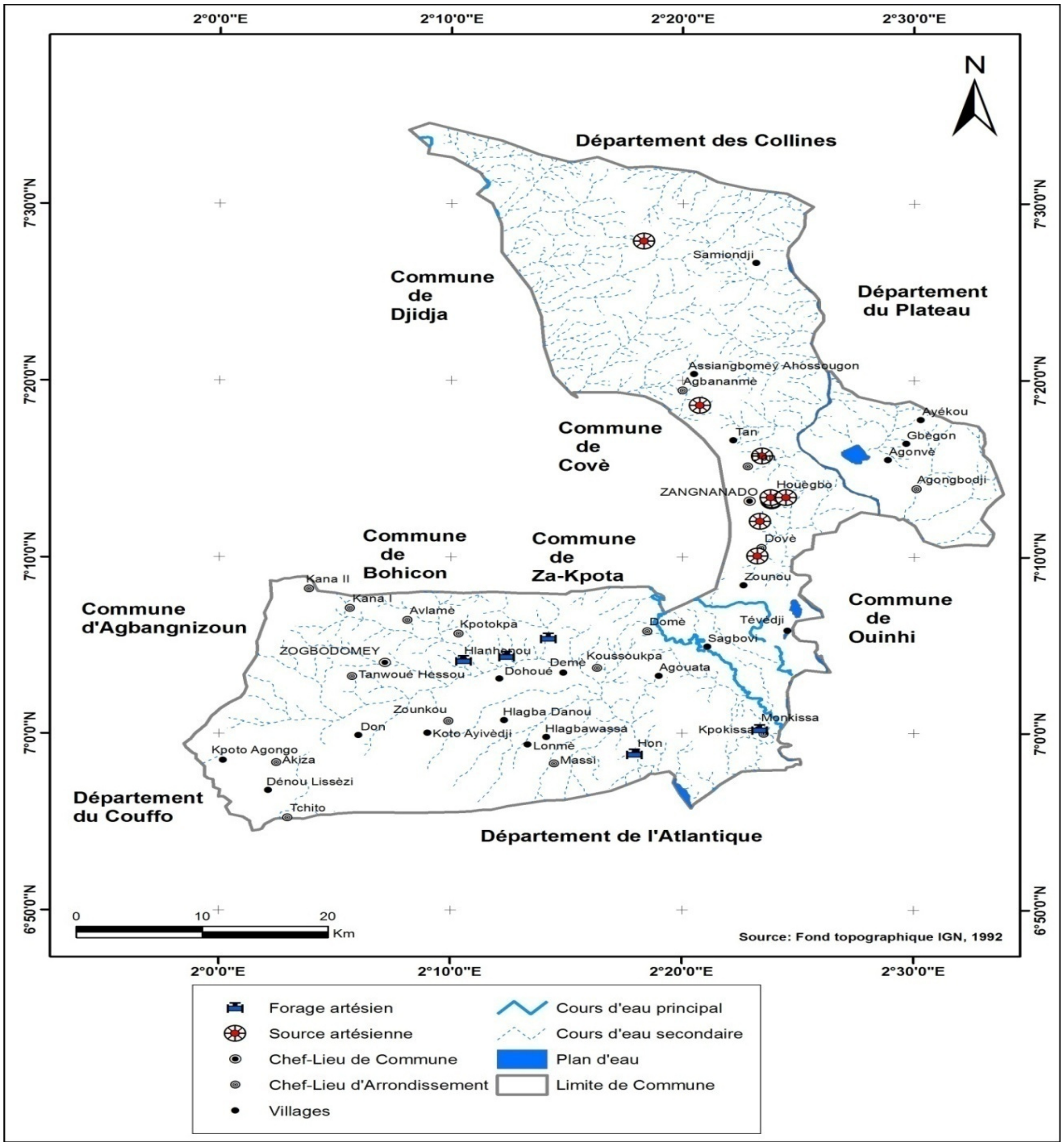


Figure 1: Location-Zagnanado Zogbodomey region

II MATERIALS AND DATA

2.1 -: Analysis hydro chemical

Water samples for laboratory analysis were taken from boreholes and artesian sources during the months of April, 2012 and 2013, and June and August 2013. These samples were made in polyethylene bottles of 1000 ml for physical and chemical analyzes. A total of 7 samples of water from artesian springs and 5 samples of water from artesian wells were collected and for laboratory analysis. The physical parameters (temperature, pH, electrical conductivity) of groundwater books were measured in situ using a pH meter and a brand conductivity meter WTW 340i field. The major elements such as chloride (Cl-), sulfate (SO 4 2-), nitrate (NO3) were analyzed by molecular absorption spectrophotometry. Bicarbonate ions (HCO3-), magnesium (Mg2 +), calcium (Ca2 +) were measured by titrimetry method. The sodium ion content (Na +) and potassium (K +) were determined by atomic absorption spectrophotometer. The analysis of geochemical data to determine the processes and sources of mineralization of groundwater is heavily based on statistical techniques (Guler et al., 2002). It is in our case the principal component analysis (PCA).

2.2-: Principal Component Analysis (PCA)

But alone does not allow statistical analysis to identify the process and sources of mineralization. We used the ion ratios to complete our study. The Piper diagram was used to define the chemical profile of the water.

PCA is a statistical techniques increasingly employed on several variables in order to identify the factors controlling the variability of geochemical data. The CPA helps to simplify and organize a wide variety of data. It provides useful generalizations that lead to significant insights. The advantage of PCR is that all the variables in a series of data can be performed simultaneously, and much more easily than is possible with traditional conventional methods of comparison of the variables in the diagrams in two dimensions (x, y) or in three dimensions (x, y, z). Most statistical techniques requires a normal distribution of data, but this requirement does not relate to the CPA because this technique is based exclusively on correlation matrices or covariances. Data on groundwater rarely normally distributed. The purpose of the ACP is to identify the variables that define the most mineralization of water, the way the ions group together and the different groups that emerge. In our case, the explanatory variables of the groups are the variables used previously for ACP .The projection of individuals in a factorial design offers the advantage of understanding the similarity or the contrast between the characteristics of individuals and the sources of their variability (Canceill M. and Landreau A., 1978). The applicability of this exploratory technique is based on the choice of the number of axes representing the maximum inertia kept with the minimum possible factors. In general, the PCR a region is only valid when the factorial study splans retain at least 70% of information (Faillat 1986; Biemi 1992). Below this limit, we consider that the study of the region did not take into account a large amount of information. Multivariate analysis was performed using the software SPSS 17.0, XL STAT. Version 2012. Results of the study are presented through the binary diagrams, spatio-temporal analysis and statistical processing.

3 -: RESULTS hydrochemistry:

3.1 : Water Temperature

Graphs 1 (a) and 1 (b) ... present the evolution of the temperature according to the season based on the location of collection. It follows that the temperatures are higher and more stable in the artesian wells (28.5 ° to 40.30 ° C, in the artesian springs (25.2 ° to 30.10 ° C).

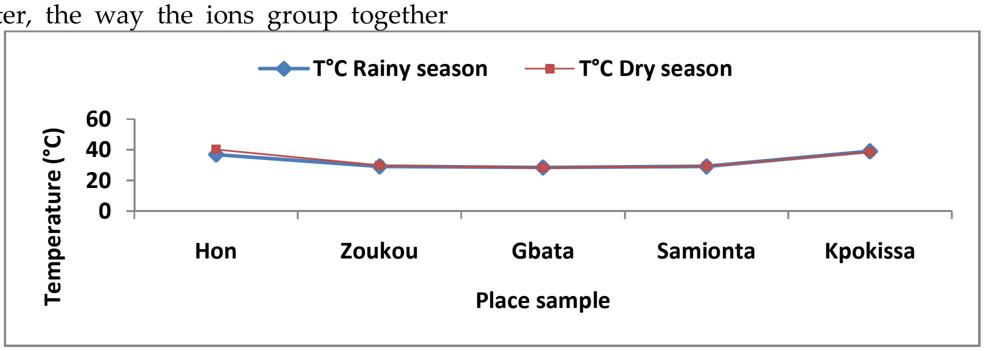


Figure 3. 1 (a): seasonal variations in temperature at the artesian wells

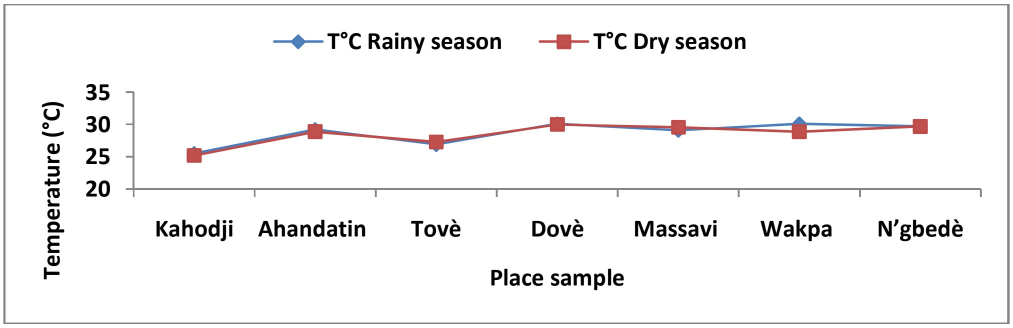


Figure 3. 1 (b): seasonal variations in temperature at the artesian springs

3.2 - Electric Conductivity

The Results of the analysis of variance showed that there is no significant difference ($p > 0.01$) between the electrical conductivity of springs and artesian wells. Similarly, no significant difference ($p > 0.01$) was observed between the conductivity of the two seasons. Reflecting stability of the mineralization.

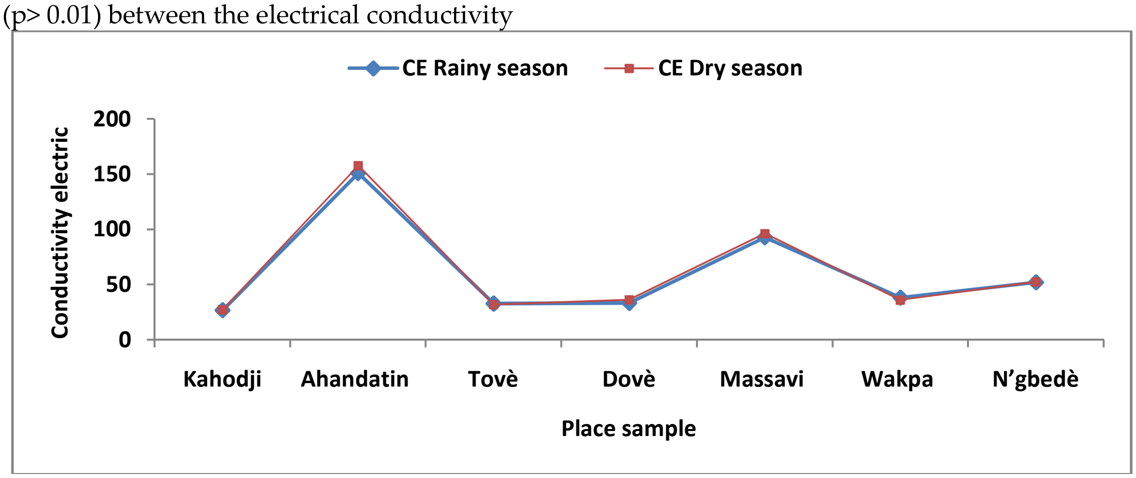


Figure 3.2 (a): seasonal variations in electrical conductivity at the artesian springs

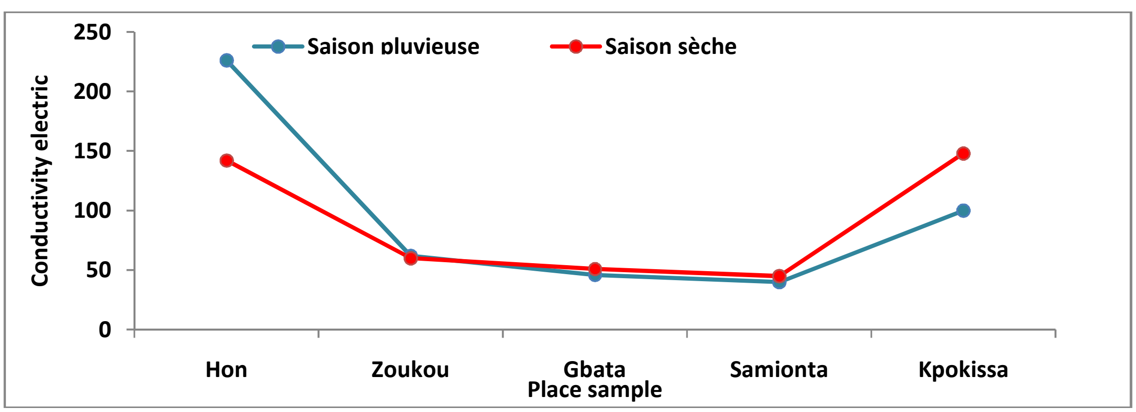


Figure 3.2 (b): seasonal variations in electrical conductivity in artesian wells.

3.3 - pH of the water

At pH artesian wells is lower in the dry season than rainy season. The same trend is observed in artesian sources Kahodji and Massavi. As against the level of other sources artesian pH is lower in the rainy season than in the dry season.

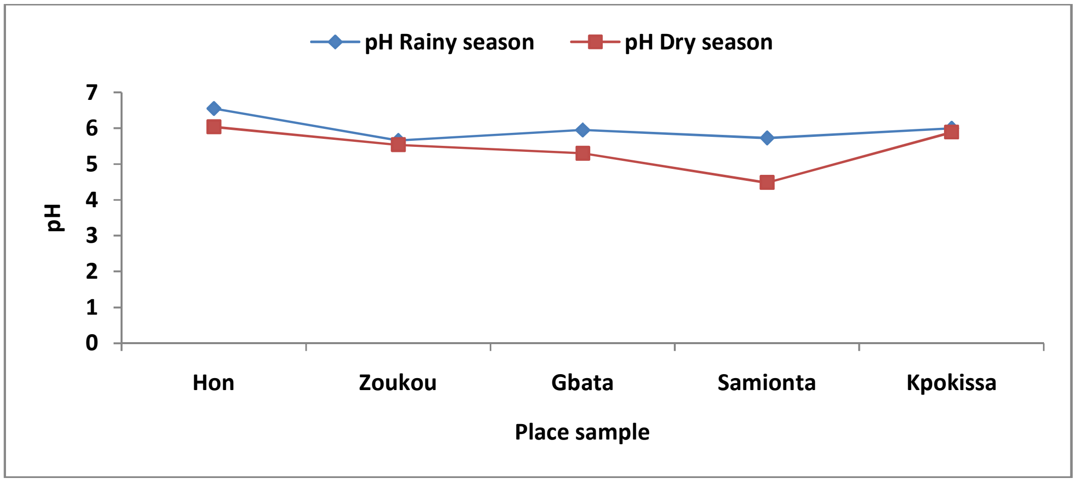


Figure 3.3 a: Seasonal variation in pH at artesian wells

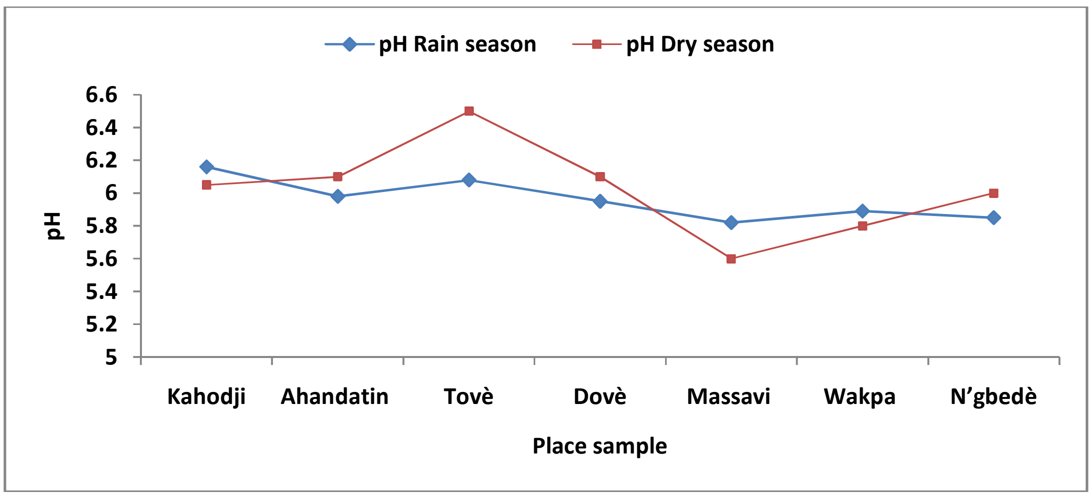


Figure 3.3.b: Seasonal variation in pH at artesian springs

3.4 -: Major Chemical elements

3.4.1 -: Levels anions

Bicarbonates dominate all anions in both water sources as artesian wells. They are followed nitrates in artesian springs and chlorides and nitrates in drilling. Sulfates are not observed in the drilling and are almost nonexistent in the sources. The minimum and maximum values of nitrates, chlorides and sulfates are respectively:

- nitrates: from 2.1 to 31.4 mg / l for the sources and from 1.9 to 15.2 mg / l for drilling. Nitrates are an important part to the mineralization of the web.
- chlorides from 0.6 to 9.7 mg / l for sources and from 2.1 to 38.69 mg / l for drilling. This is one of the major components of the medium that determines the chemical profile of the water in the region.
- sulphate 0 to 4 mg / l for the sources

The sulphate content is acceptable according to WHO standards (400 mg / l) as well as the nitrate content values are well below the drinking water standards accepted by the WHO (<50 mg / l)

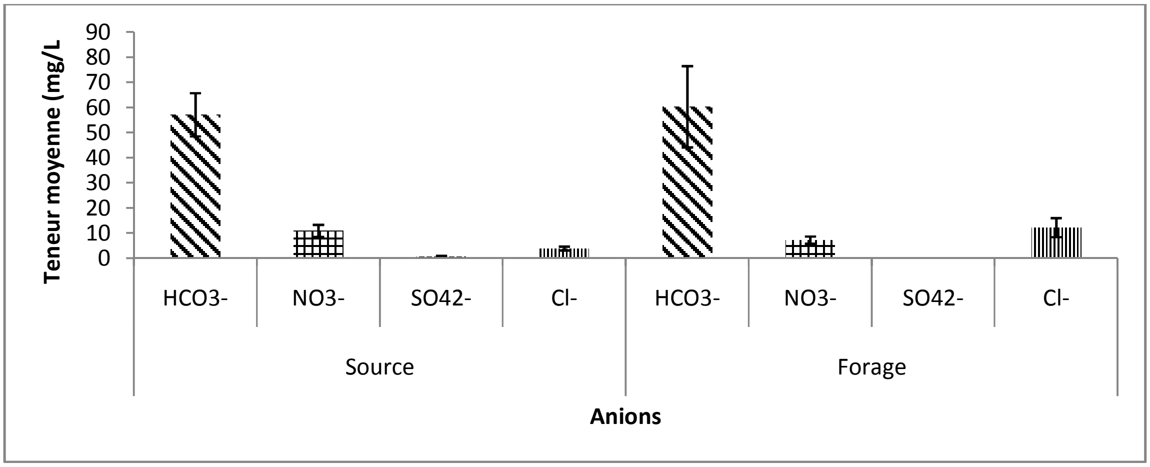


Figure 3.4: ion concentrations in water wells and artesian sources

3.4.2 -: Levels cations

Calcium, magnesium and sodium are present in the waters of artesian springs compared to potassium. Sodium is present in the drilling water compared to other cations, it is followed respectively calcium, magnesium and potassium.
-The minimum and maximum values of calcium, magnesium, potassium and sodium are respectively:

- calcium: from 2.65 to 40.6 mg / l for the sources and from 1 to 51.31 mg / l for drilling
- magnesium: from 0.30 to 19.3 mg / l for the source and from 0.46 to 16.77 mg / l for drilling
- potassium: from 0.6 to 17.9 mg / l for sources and from 0.5 to 15.03 mg / l for drilling

o-sodium: from 1.9 to 14.08 mg / l for sources and from 3.36 to 62.32 mg / l for drilling

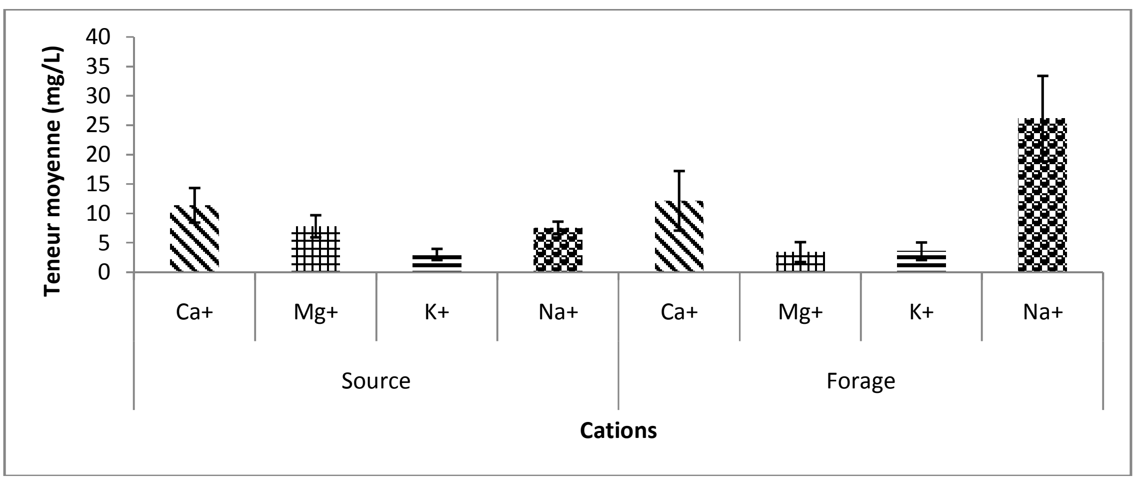


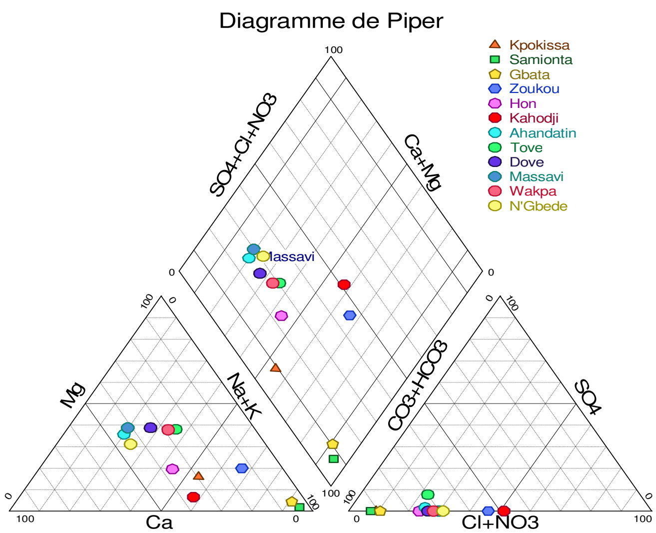
Figure 3.5: Concentrations of cations in water boreholes and artesian sources
The calcium, magnesium, potassium and sodium are acceptable according to WHO standards

3.5 -: Chemical Facies water

The chemical profile of water was typically determined using the Piper diagram, using the diagram software Hydrogeology Laboratory of Avignon [Simler, 2007]. The data of major ions, plotted on this diagram (Figure 3.6) have identified four types of chemical facies of groundwater in the study area.

The typology is based on the major ion contents contained in the water. Cations (Ca2 +, Na +, Mg2 +, K +) and anions (HCO3-, Cl-, SO42-, NO3-) combine in pairs to form the main hydrofacies zone. These hydrofacies are based on the dominant anion and the cation dominant: A calcium bicarbonate type facies, baking is the dominant anion and calcium cation dominant in the analyzed water.

(a) Rainy season



(b)Dry season

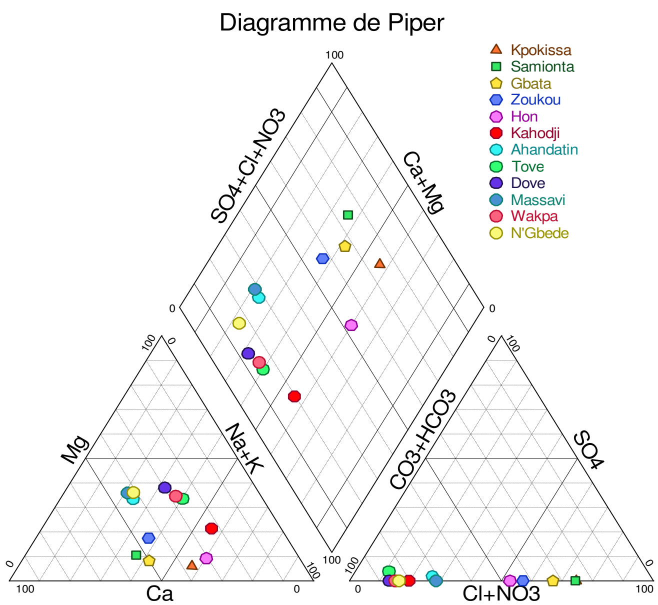


Figure 3.6: geochemical facies of groundwater in the rainy season (a) and dry season (b) in the region of Zagnanado and Zogbodomey

Table 3.1: Seasonal geochemical facies of water sources and artesian wells in Zogbodomey and Zagnanado

Geochemical facies	**Rainy season**	**Dry season**
And chlorinated lime magnesium ***(Cl-Ca-Mg)***	- Source de Kahodji	-Forage de Samionta -Forage de Gbata - Forage de zoukou
Calcium bicarbonate and magnesium ***(Ca-Mg-HCO3)***	- Forage de Hon - Source de Ahandadin - Source de N'gèdè -Source de Massavi -Source de Dovè -Source de Wakpa -Source de Tovè	-Source de Ahandatin -Source de Dovè -source de N'gbèdè -Source de Massavi -Source de Tovè -Source de Wakpa
Sodium bicarbonate and potassium ***(Na-K-HCO3)***	- Forage de Samionta -Forage de Kpokissa -Forage de Gbata -Forage de Zoukou	-Source de kahodji
the sodium chloride ***(Na-Cl-no3)***		-Forage de Hon -forage de Kpokissa

3.6 -: Major ion Relationship bicarbonates

Figures 3.7 and 3.8 show the relationships between the major cation contents individually and bicarbonates in the water sources and wells. A linear correlation between the Mg 2+, Na +, and especially the Ca 2+ ion with bicarbonates in the waters of artesian springs. This increasing trend is less meaning with potassium. If it is accepted that the Mg 2+ ion mostly comes from silicate weathering mafic minerals, a significant portion of Ca2 +, Na +, and K + has an origin dependent hydrolysis minerals. This confirms the dominant role in the chemistry of carbonates. Bicarbonates are produced following the transfer of CO2 by water infiltration, by hydrolysis reaction which allows on one hand, the formation of HCO3- and second, increasing the pH assuming evolution in a closed environment. This is the basis of these facts that the use according hydrogéoloques (Babaye, 2012), HCO3- or pH to link the contact water-rock, and the production of ion in water. So the water remains in contact with the rocks over the hydrolysis time to perform normally etpar Therefore, the more water will be mineralized. The relationship is not linear with the same ions in the water holes, but it is significant.

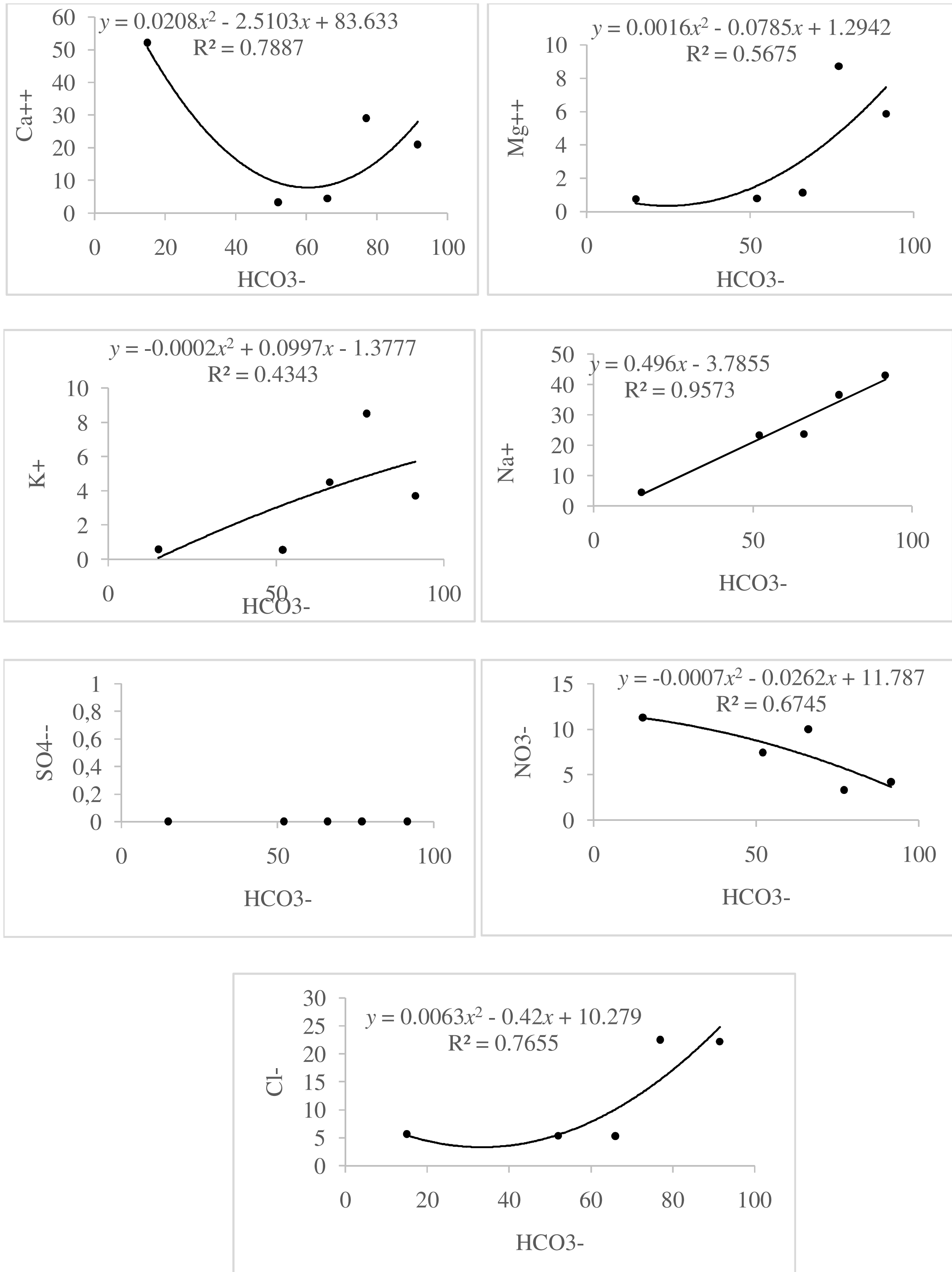


Figure 3.7 -: Relationship bicarbonates and major ions in artesian wells

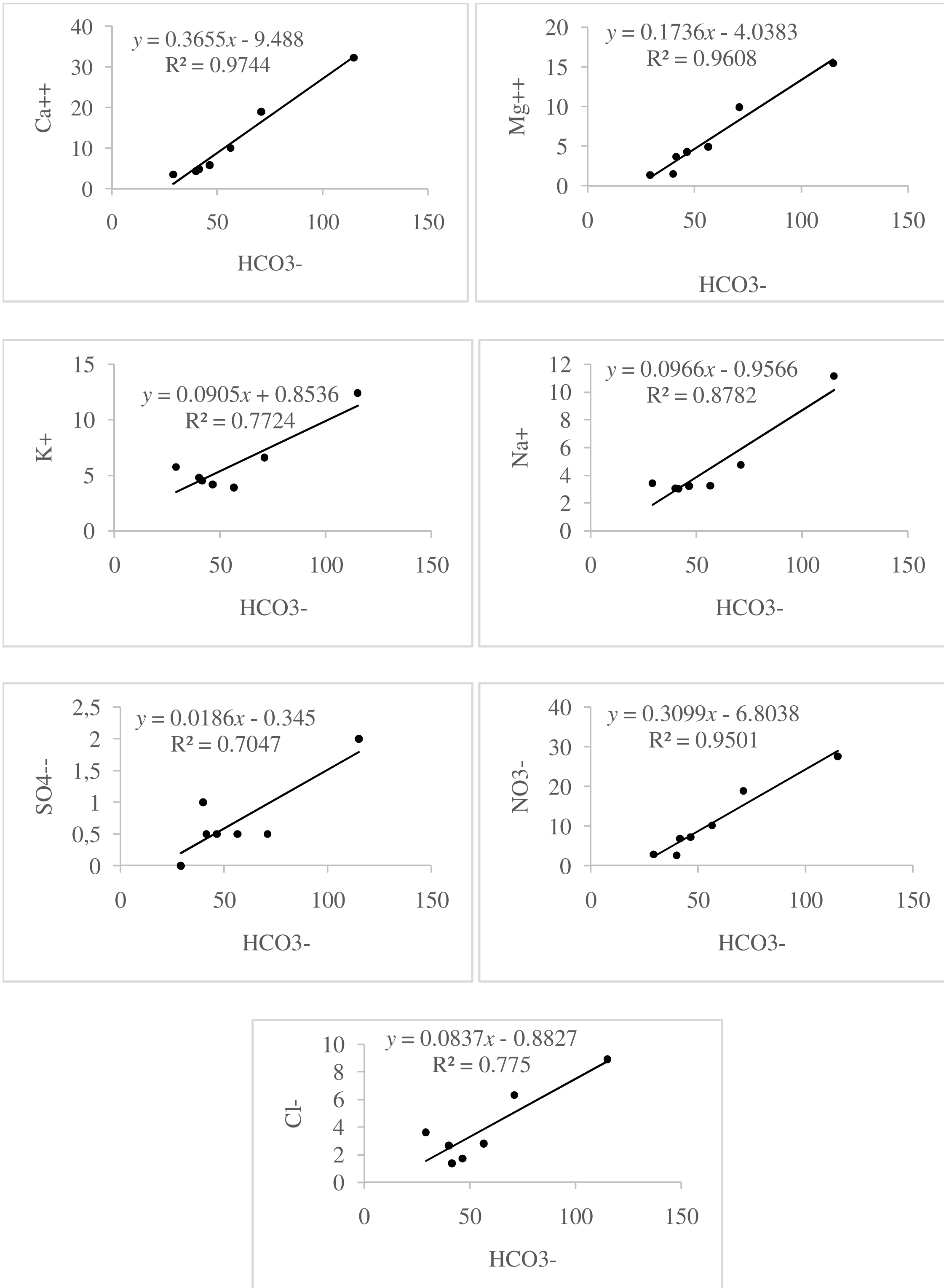


Figure 3.8 -: Relationship bicarbonates and major ions in artesian springs

3.7-: total mineralization and major ions in the sources Relationship

Figures 3.9 and 3.10 show the proportion of each ion in the mineralization of waters. These results highlight the alkano earth Ca2 + Mg2 + are strongly related to the total mineralization of water artesian springs (R^2 = 0.98 and R^2 = 0.95). The Na + also displays a remarkable connection with the total mineralization (R^2 = 0.90), then comes the K + ion with (R^2 = 0.82). This order is different in water wells that show a wide importance of the Na + ion then comes after the Ca2 + ion and then ion Mg 2+. At the anions, there is the preponderance of HCO3- ion over other anions (NO3-, Cl- SO4-) in water sources that are abundant accidentally. The frequency of the Cl ion and its regular layout reveals its dominance on NO3- ion and its significant importance in the total mineralization of water from artesian wells.

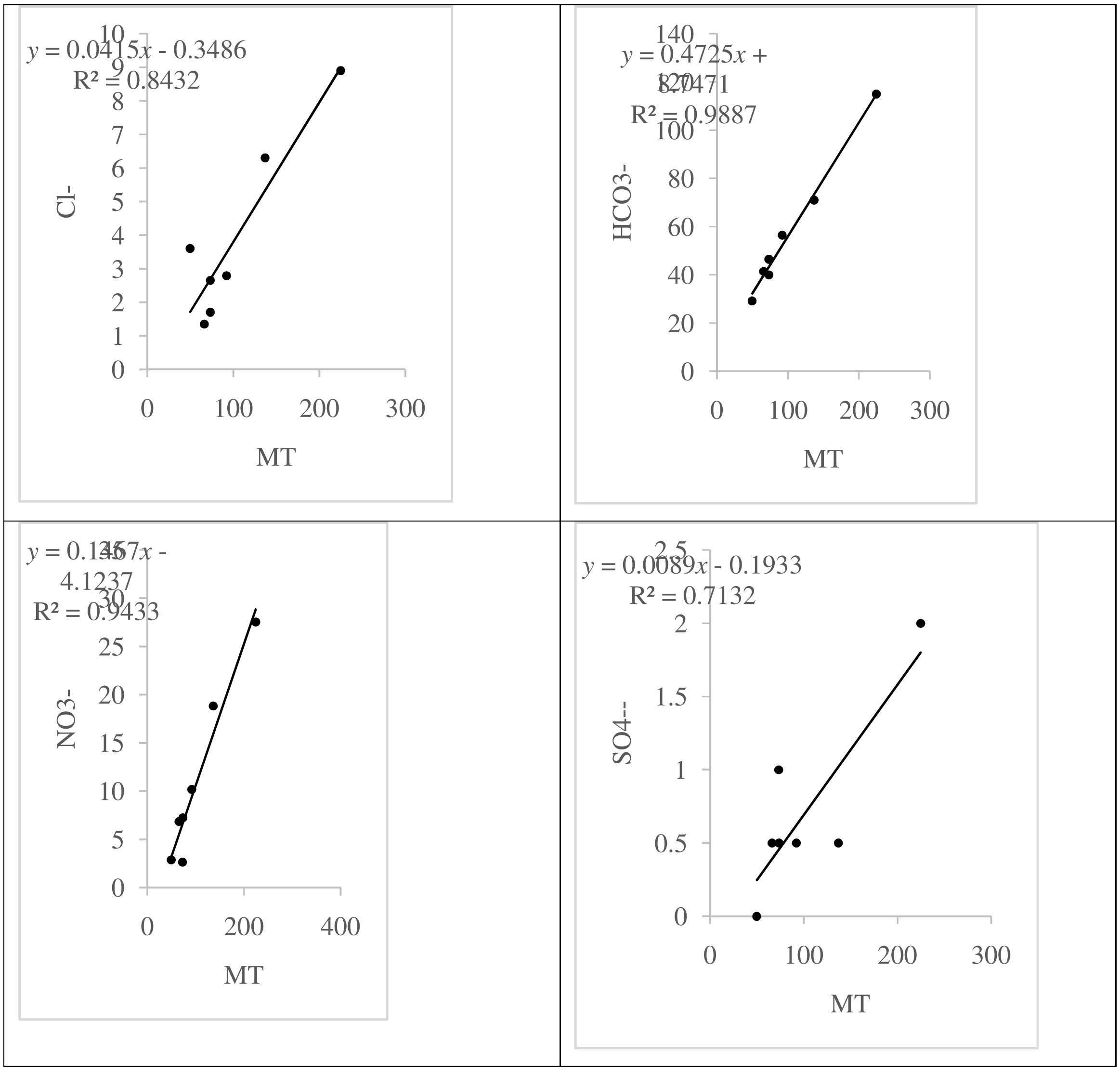


Figure 3.9 (a) : total mineralization and major ions in Relation artesian springs

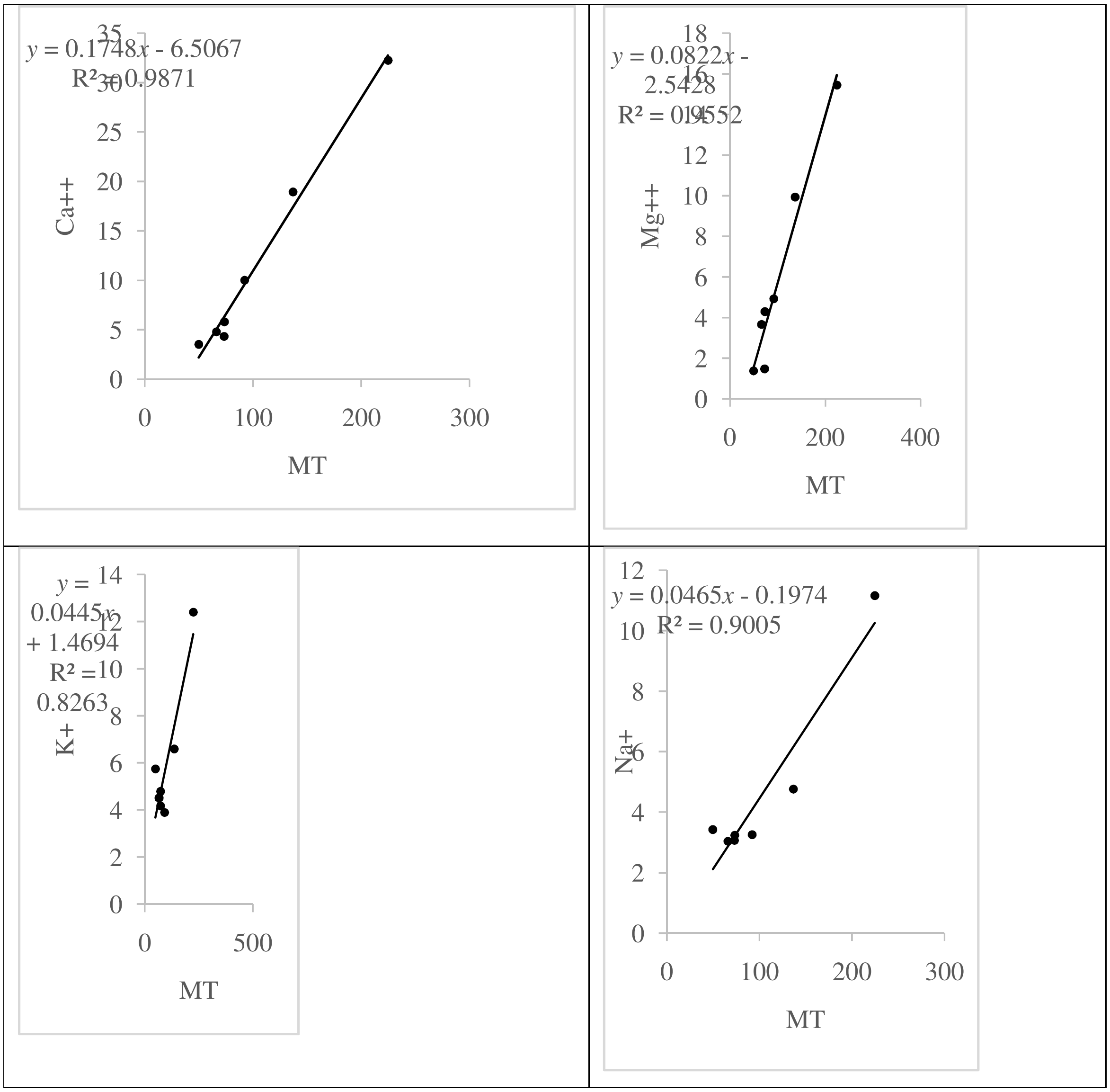


Figure 3.9 (b) : total mineralization and major ions in Relation artesian springs

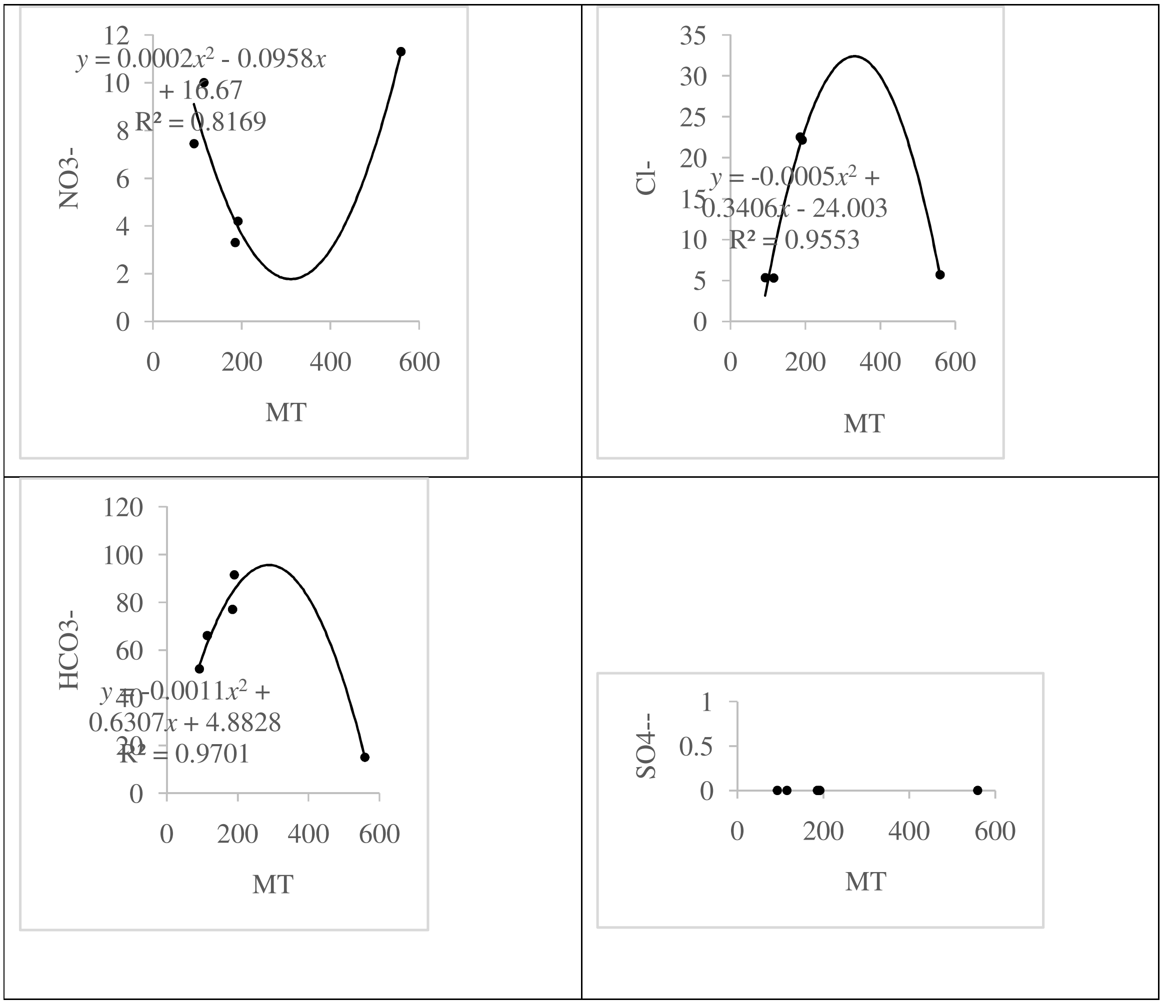


Figure 3.10 (a) : total mineralization and major ions in Relation artesian springs

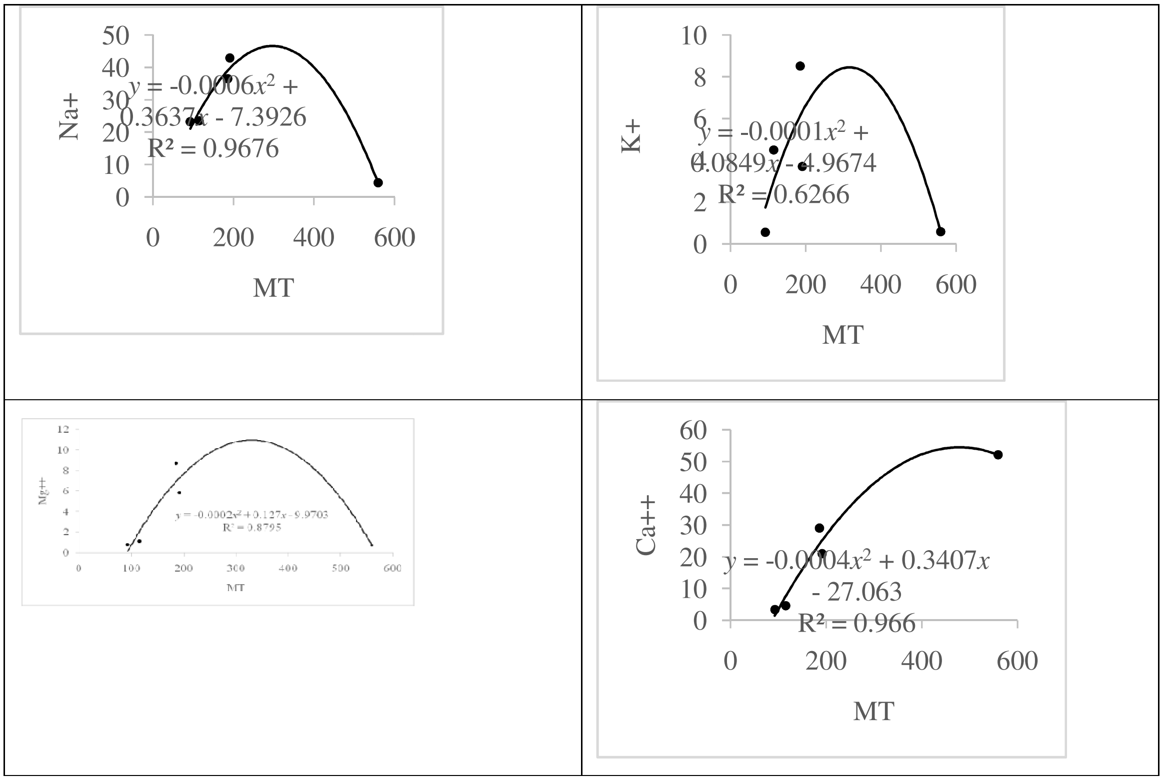


Figure 3.10 (b) : total mineralization and major ions in Relation artesian spring

3.8 - Binary Relations between sodium and chloride

In the event that the sodium and chloride ions have originated seawater thanks to the contributions of the rains (the study area is approximately 150 km from the Atlantic coast), the ion ratio Cl / Na + (ion ratio in mg / l on mg / l) should be identical to that of seawater, therefore close to 1.8. These ions ratio Cl / Na + are significantly below this value for all drilling and artesian springs in the rainy season and were above 1.8 for the following drilling Hon (1.98), Zoukou (2 , 74) and Gbata (2.02) in the dry season. At the artesian springs, always dry season, we got to Kahodji (1.96) and Massavi (2.54) Table 3.2

Table 3.2: Evolution of chloride contents based on sodium contents.

Rainy season

Param	Hon	Zoukou	Gbata	Samionta	Kpokissa
Cl^-	23,8	2,2	2,2	2,1	5,7
Na^+	62,32	5,5	42,23	40,34	56,86
cl-/Na	0,38	0,4	0,05	0,05	0,10

Dry season

Param	Hon	Zoukou	Gbata	Samionta	Kpokissa
Cl^-	21,3	9,23	8,52	8,52	38,69
Na^+	10,74	3,36	4,2	6,77	28,94
cl-/Na	1,98	2,74	2,02	1,25	1,34

Rainy season

Param	Kahodji	Ahandatin	Tovè	Dovè	Massavi	Wakpa	N'gbedè
Cl^-	2,6	8,1	2,6	1,7	4,7	0,6	2,28
Na^+	4,51	8,23	4,03	3,07	6,41	4,17	3,75
Cl-/Na	0,57	0,98	0,64	0,55	0,73	0,14	0,61

Dry season

Param	Kahodji	Ahandatin	Tovè	Dovè	Massavi	Wakpa	N'gbedè
Cl^-	4,6	9,7	2,7	1,7	7,9	2,1	3,3
K^+	2,34	14,08	2,1	3,4	3,1	1,9	2,75
Cl-/Na	1,96	0,68	1,28	0,5	2,54	1,11	1,2

DISCUSSION

4.1-: Water Temperature

The results of the ANOVA showed that there was a significant difference ($p < 0.01$) between the temperature of the water source and artesian wells. Artesian wells showed a higher average temperature (32.95 ± 1.59) and the artesian springs an average of (28.58 ± 0.45) according to the Student test Newman-Keuls. These data, close to atmospheric average temperature of the study area (32.8 ° C), indicate a thermal equilibrium between the aquifer and the atmosphere. Graphs 1a and 1b show the seasonal variations of temperature in the waters of artesian wells and springs. In the drilling and Hon Zoukou, the temperature of the dry season the water is higher than the temperature in the rainy season by cons in drilling Gbata of Samionta and Kpokissa, no difference was observed between the temperatures dry season and the rainy season. Otherwise at the artesian wells, a large variation of the temperature is observed by the season in the sources. Indeed sources Kahodji, Ahandatin, Dove and Wakpa have a lower temperature in the dry season than rainy season while the sources of Tove and Massavi have a high temperature, as in the dry season than in the rainy season. However, the temperature at the source of N'gbèdè has not changed regardless of the season. Temperatures remain stable throughout year except the source of Wakpa and drilling Hon. Temperatures remain stable throughout the year except the source of Wakpa and drilling Hon. Changes in the temperature of the water sources and wells appear to follow seasonal changes of the average air temperature in the study area (32.8 ° C). This confirms the influence of climate on groundwater resources shallow region. High temperatures are recorded at the boreholes, and the lowest is recorded in the sources . This is underlined by Babaye (2012) , which affirms that the highest temperature values are encountered in deep aquifers and lowest values are recorded in the superficial layers .

4.2 - Electric Conductivity

The stability of the mineralization observed at most of the works can be conveyed by the absence of the rainy season in phenomena of dilution and non increased mineralization in the dry season. This feature is explained by the fact that drilling and artesian sources are located in areas where recharge often reaches late the tablecloth (confined aquifer) and the presence of a clay layer that prevents the vertical infiltration . However, at the artesian wells of Hon Kpokissa and a respective difference 184 S / cm and 48 S / cm was observed between the dry season and the season. Indeed, the mineralization remains high compared to the rainy season in the waters of drilling Hon. As against it is higher during the dry season than the wet season in the waters of drilling Kpokissa. The hydrodynamics of groundwater is a major determinant of the change in the mineralization of groundwater. Indeed, in the rainy season, water flows into underground reservoirs result in the dilution phenomenon and decreased mineralization rate (if water drilling Kpokissa). Alassane (2002), supported by Totin (2010) explains that the great drought which lasts from December to April can promote evaporation phenomena probably the origin of the strong mineralization of the waters in this period. The increase in mineralization loading time (if the drilling Hon) may be due either to the dissolution of minerals located in places of geological formations, or the arrival of sewage into these areas of Boukari table (1998) and Alassane

(2002). Artesian springs are located in areas where recharge belatedly reached the table, because of its great depth or the presence of a clay layer that prevents the vertical infiltration; all this results in the absence of dilution phenomena and increased mineralization.

. Artesian wells have conductivities ranging from 40-226 μS.cm-1 and an average of 94.8 μS.cm-1 in the rainy season. Artesian springs are generally low conductivities ranging from 27 to 157.5 μS.cm-1 with an average of 62.2 μS.cm-1 in the dry season. The decrease in conductivity is due to the process of mixing between recent recharge waters and waters of the aquifer by the phenomenon of diffusivity . The increase in conductivity observed after the rainy season is due to the contributions of more mineralized surface water (Hassan , 2010). The stability of the electrical conductivity in some locations is justified by the fact that the charging has not yet reached the web this because of the piezometric surface which is very deep or because of the presence of a layer of clay which prevents vertical infiltration .

Aquifers and aquifer crutacé of limestone Eo-Paleocene of the common Zogbodomey and Cretaceous (Turonian - Coniacien) of the Common Zagnanado are predominantly sandy and sandy clay , or intercalation with conglomeratic levels (conglomerate base) and oolitic . These siliceous dominant formations are few minerals . The geological nature of the soil formations and ZNS are factors that influence changes in the electrical conductivity (Hassan , 2010). According Babaye , (2012) in a recent study on Dargol Basin in Niger , the pH values and those of the electrical conductivity is high in the dry season (low water) and fall after the rainy season (high water) . However, some contaminated wells observe the opposite effect due to the contribution of NO3 ion by seepage causing increased water mineralization . As for Adiaffi (2009), in a study on the contribution of isotope geochemistry, water chemistry and Remote Sensing to the knowledge of aquifers in the area of contact " base - sedimentary basin " South eastern coast ivory , he stated that the layers of the sedimentary basin (including that of the Continental Terminal) are weakly mineralized and the trend shows that groundwater appear to change over time . They become more and more acidic and less mineralized. This statement is the result of collection of data on temperature, pH , electrical conductivity for three years. Our observations on these three parameters are made only for one or two seasons. It would be difficult to talk about their evolution.

4.3 - pH of the water

PH artesian wells is in the range of 4.4 to 6.5 with a mean of 5.4 and a standard deviation of 0.6 and in the range of 5.6 and 6.5 for the sources artesian with a mean of 6.0 and a standard deviation of 0.2. The lowest pH were measured in water from artesian wells. The highest pH values are found in the waters of artesian springs. And drilling water has a relatively acidic pH with an average of 5.4. As against the sources whose average pH is close to neutral. This tendency to neutrality in the waters of artesian springs is due to the consumption of CO2 following the hydrolysis of silicate causing increased alkalinity (HCO3) water (Schoeller, 1962; Faillat and Drugs, 1993 cited by Babaye, 2012). In contrast the results of drilling of water acidity are consistent with those of (Boukari, 1998; and Alassane 2004; quoted by Totin, 2010) for which the silicate nature of the tanks or the dissolution of the acid carbonate from atmospheric CO2 can explain this acidic groundwater. The lowest pH were measured in the Paleocene limestone aquifer (IIb unit) (Lama depression) who is confined aquifer under the argillites and marls of Upper Paleocene and Lower and Middle Eocene . Its thickness varies only a few meters to thirty meters maximum. The highest pH values are found in the groundwater in the aquifer of the Cretaceous (Turonian - Coniacien or Unit I) north of the depression of the Lama, where sandy Coniacien flush and captive under the Maastrichtian marls and argillites and the Eocene to the south, where the sinks quickly Coniacien. These different observations show that the waters of crutacé and Eocene in the town of Zogbodomey are predominantly acidic tendency in the town of Zogbodomey , while the waters of the sheet of the Cretaceous aquifer (Turonian - Coniacien) of the common Zagnanado slightly basic or neutral . These various results are consistent with the geological nature of aquifers in dominant acids whose dominant facies is represented by sand and fine quartz sandstone and greenish gray clays , kaolin puff , and aquifers dominance in neutral or slightly basic with the dominant facies is represented by the deposits formed quartz sand , sandstone or siliceous ferruginous cement with kaolin clay and quartz gravels angular to rounded , reflecting a similar origin (Hassan , 2010).

4.4 -: Chemical Facies water

Regarding chemical facies Ahandatin artesian water sources, N'gbède, Masavi, Dove, Tove, Wakpa type calcium bicarbonate, magnesium in the rainy season does not experience variation in dry season. The water from the source Kahodji calcium chloride-facies in the rainy season passes facies sodium bicarbonate in the dry season. At the level of drilling Samionta, Gbata, Zoukou, Kpokissa, the water initially facies bicarbonate sodium and potassium in the rainy season has become chlorinated lime for drilling Samionta of Gbata and Zoukou. However water drilling Kpokissa initially facies sodium and potassium bicarbonate water well drilling Hon calcium bicarbonate facies in the rainy season pass to chlorinated sodic facies in the dry season.

Of the rainy season to the dry season, is observed dynamics of geochemical facies in water (artesian wells) while it remains unchanged for almost all water sources except artesian water source Kahodji. These variations are attributed according Mudry (1987) cited by Totin (2010) to the estate of hydrological events (which alter the quantity and quality of water in the aquifer), and you may have other processes Internal to the system (such as the physico-chemical interactions between the phases). Each water is unique and its nature depends on the chemical composition of the rocks through which it passes and mixtures may occur. There is therefore no one but the qualities of the water. Groundwater is more or less mineralized depending on the nature of the rocks; the water contact time with the rock minerals, therefore the water percolation rate; time for renewal of the water table by seepage water. Of the rainy season that sèches'observe dynamic geochemical facies in water (artesian wells) while it remains unchanged for almost all water sources except artesian water source Kahodji. These variations are attributed according Mudry (1987) cited by Totin (2010) to the estate of hydrological events (which alter the quantity and quality of water in the aquifer), and you may have other processes internal to the system (such as the physico-chemical interactions between the phases). In general, calcium bicarbonate facies dominates all others in filing the results of this study, 58 %. This trend is confirmed by previous work in Senegal (Diouf, 1999) , Côte d' Ivoire (

Faillat 1986; Biemi 1992; Adiaffi , 2008 Oga et al ., 2009) in Burkina Faso (Yameogo 2008) , Benin KAMAGATE , 2006). The waters of this group show a dominance of alkano earth ions on alkaline (Babaye , 2012). The bicarbonées sodic waters cover five books. They are characterized by the dominance of the alkano alkaline earth metal and also by the low value of electrical conductivity (Babaye , 2012). Drilling artesian Samionta , Kpokissa , Gbata , Hlanhonou and source Kahodji respectively 40.34 mg / L, 56.86 mg / L, 42.23 mg / ; 5.50 mg / l; 10.90 mg / l of sodium contents against 1.44 mg / l, 28 mg / L , 1.96 mg / l 1.04 mg / l 4.4 mg / l calcium. The water of this group have sodium contents of two to twenty eight times greater than those of calcium. The trend achieved in the work of Babaye is of the order of (Na + > 1.5 Ca2 +).

4.5: Major ion Relationship bicarbonates
A linear correlation between the Mg^{2+}, Na $^{+}$, and especially the Ca^{2+} ion with bicarbonates in the waters of artesian springs. This increasing trend is less meaning with potassium. If it is accepted that the Mg^{2+} ion mostly comes from the weathering of silicate ferromagnesian minerals, a significant portion of Ca^{2+}, Na^{+}, and K^{+} has an origin dependent hydrolysis minerals. This confirms the dominant role in the chemistry of carbonates. Bicarbonates are produced following the transfer of CO_2 by water infiltration, by hydrolysis reaction which allows on one hand, the formation of HCO_3^- and second, increasing the pH assuming evolution in a closed environment. This is the basis of these facts that the use according hydrogéoloques (Babaye, 2012), HCO_3^- or pH to link the contact water-rock, and the production of ion in water. Thus, the water remains in contact with the more hydrolysis rocks time to perform and therefore normally, the more water will be mineralized. The relationship is not linear with the same ions in the water holes, but it is significant.

4.6: Relation total mineralization and major ions in the sources and boreholes
Total mineralization in the relationship and major ions in the sources and boreholes in the region, the results highlight that alkano earth Ca^{2+} Mg^{2+} are strongly related to the total mineralization of water artesian springs (R2 = 0.98 and R2 = 0.95). The Na + also displays a remarkable connection with the total mineralization (R2 = 0.90), then comes the K + ion with (R2 = 0.82). This order is different in water wells that show a wide importance of the Na + ion then comes after the Ca^{2+} ion and then ion Mg^{2+} . At the anions, there is the preponderance of HCO_3^- ion over other anions (NO_3^-, Cl^-, SO_4^{2-}) in water sources that are abundant accidentally. The frequency of the Cl^- ion and its regular layout reveals its dominance on NO_3^- ion and its significant importance in the total mineralization of water from artesian wells. The positive trend between HCO_3^- ion and total mineralization confirms the main source of this element dissolution silicate minerals. These analyzes clearly within the role of each ion in the mineralization of the water. It is found that, just as the majority ions (Ca^{2+}, Mg^{2+}, Na^+ and HCO_3^-), accidental ions such as (NO_3^-, Cl^-, SO_4^{2-}), also have an influence on the mineralization of the water.

4.7 - Binary Relations between sodium and chloride
In the event that the sodium and chloride ions have originated seawater thanks to the contributions of the rains (the study area is approximately 150 km from the Atlantic coast), the ion ratio Cl^- / Na^+ (ion ratio in mg / l on mg / l) should be identical to that of seawater, therefore close to 1.8. This feature

when it is in the dry season observed ion reports Cl- / Na + above 1.8 is explained by the fact that drilling and artesian sources are located in areas wherein the refill often reached late the web (confined aquifer) and the presence of a clay layer that prevents vertical infiltration. All other ion report data Cl^- / Na^+ Who are significantly below 1.8 rather reveal behaviors related to the effect of anthropogenic pollution, and to a lesser extent, the sodium intake by interaction water- rock.
The frequency of the ion NO3- reveals its dominance on Cl^-, SO_4^{2-}, and its significant importance in the mineralization of water from artesian springs.

Water characteristics of sources and artesian wells

In both seasons, the mineralization of water from artesian springs includes electrical conductivity , nitrates , potassium , chloride , sodium, calcium and magnesium sulphates . Dassi (2011) states that the primary source of mineralization is the dissolution , while the second is due to anthropogenic processes. Major ions follow the following distribution: $Ca^{2+} > Na^+ > K^+ > Mg^{2+}$ for cations and $HCO_3^- > NO_3^- > SO_4^{2-} > Cl^-$ for anions in the waters of the Cretaceous formations in the argillites and marls Maastrichtian (artesian springs) . Previous work by (the Vaissière , 2006; Diaw, 2008; Yaméogo , 2008; quoted by Babaye , 2012) showed that Ca^{2+} , Mg^{2+} are generally provided by the hydrolysis , so deep origin, while the NO3- ions are generally the superficial sources. Major ions follow the following distribution: $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ cations for and $HCO_3^- > Cl^- > NO_3^- > SO_4^{2-}$ for anions in the waters of artesian wells. The geochemistry of water drilling has highlighted the sensitivity of the aquifer to surface pressures. Drilling water are mainly characterized by a deficit in Ca2 + bound to relatively high contents of Na + . A cation exchange process seems to occur in aquifers Eocene leading to preferential adsorption of divalent cation , leading to a concentration in the solution of the Na^+ ion, leaving a deficit of Ca^{2+} and Na^+ enrichment (Hassan , 2010). The presence of NO_3^- ions in this group expresses the influence of anthropiques Activities in the acquisition of the mineralization of water artesian springs. Nitrates are very good indicators of diffuse pollution. They have as main natural degradation of organic matter , which brings their maximum concentration in groundwater about 12 mg / L (Desbordes , 2001). The relationship between nitrate levels and concentrations of sulfates and chlorides elements can then be used to distinguish the origin of these minerals. Whether in the water sources that water artesian wells nitrates are correlated with chlorides. The relationship between the two elements , confirming that the chlorides come mainly from human activities. The agriculture and livestock provide various chemical elements (Na +, NO3- , Cl-, SO_4^{2-}) which are driven up to the web by seepage (Babaye , 2012). The beginning of nitrated pollution in the study area , prompts us to seek the origin of this ion . CPA conducted on groundwater showed that NO3 ion is from surface. Also, the relationship with nitrates chlorides showed the common origin. If we accept the hypothesis that nitrates are from surface, the web thus have its maximum at the end content rainy seasons (Babaye , 2012). To test this hypothesis, it was highlighted the change in nitrate levels between the rainy and dry season. From our observations , it appears that almost all sources reached the highest value of nitrate during the rainy season Massavi (21.8 mg / l against 15.9 mg / l) , Wakpa (7.1 mg / l against 6 5 mg / l) , Ahandatin (31.4 mg / l against 23.7 mg / l) , N'bèdè (10.5 mg / l against 8.8 mg / l) Dove

(7.4 mg / l against 6.1 mg / l) (Hamza et al ., 2007; . et al Saadi 999). Nitrate (NO_3^-) and nitrite (NO_2^-) ions are naturally present in the environment. They are the result of nitrification of the ammonium ion (NH4 +) in the water and soil, which is oxidized to nitrites by bacteria of the genus Nitrosomonas , and then into nitrates by bacteria of the genus Nitrobacter (INSP Quebec , 2003). In unpolluted waters, the nitrate level is very variable (from 1 to 12 mg / L) , according to the season and the origin of water (Desbordes , 2001). The presence of nitrates above the levels of 12mg / l in drinking water is primarily due to human activities (INSP Québec , 2003). The nitrate problem is the consequence of the development of live livestock one hand, and the massive use of fertilizers for cash crops like cotton on the other . There are in the town of Zogbodomey , according to statistics from CeCPA in 2013, 70 427 poultry heads 12,000 heads of small ruminants and 2,991 head of cattle . On the other hand, to Zagnanado , there are 63,400 poultry heads, heads 32415 sheep and goats and pigs 31700 heads. There are virtually no adequate pastoral infrastructure in both municipalities. These animals left straying pollute the environment through their droppings. Non mastery of farming techniques, lack of access to veterinary care we are unfortunately witnessing a strong small ruminant mortality rates . Often dead animals are thrown on rubbish heaps.

Nitrogen is an essential component of all living beings as part of the composition of proteins and nucleic acids. Nitrates can come from organic waste (human and animal) . In rural areas , pollution is mainly related to cash crop production that requires the application of pesticides and fertilizers . Often these products are used in excess, this has a negative influence on the ground. The concentration of groundwater in the study area is at given locations close to 50 mg / l, acceptable limit for human consumption by the WHO. When considering the Decree 2001-094 of 20 February 2001 for the protection of water intended for consumption, nitrate concentration of groundwater is above 45 mg / l, Dohounmè , Assiangbomé in the town of Zagnanado and Avlamé kotokpa 2 in the town of Zogbodomey. The results of our study also show that the population buys water in artesian wells studied consumes water of between 1.9 and 15.2 mg / L of nitrate and one that buys in the sources studied consumes water having between 2.1 and 31.4 mg / L. Human activities have an impact on the quality of water from artesian springs and boreholes common Zagnanado and Zogbodomey . The quality of groundwater is affected by high nitrate levels in the years to come, tribute to the strong agricultural yields. Unlike in Europe (Martelas et al , 19997 ; . Hallet , 1998; Marjolet et al ., 2000; widory et al ., 2004; Durand, 2005; Orban, 2009) and North Africa (Saadi et al, 1999 ; Hamza et al, 2007) where diffuse pollution related to agricultural activities is dominant, the Sub-Saharan Africa is more subject to occasional pollution due to sewage effluent and / or latrine (Nkotagu , 1996; Girard, 1993; et al Tandia . 1999) and livestock (Diouf , 1999).

Conclusion

The objective of this study was to compare the water sources and artesian wells with the addition of water chemistry. The hydrochemical standpoint, water artesian springs have a chemical signature similar to that of water artesian wells. The pH of the artesian water sources varies from 5.6 to 6.5 while that of water artesian wells is between 4.4 to 6.5. The electrical conductivity of the water sources varies from 27 to 157.5 μS.cm-1 and the borehole between 40-226 μS.cm-1. Calcium (Ca^{2+}) is the principal cation and anion is the main carbonate ion (HCO_3^-) for water artesian springs. While sodium (Na +) is the major cation and anion is the main carbonate ion (HCO_3^-) for water from artesian wells. Of the rainy season to the dry, is observed dynamics of geochemical facies in water (artesian wells) while it remains unchanged for almost all water sources except artesian water source Kahodji. Comparison of ion ratios Cl^-/ Na^+ are more students in the waters of artesian wells as water artesian springs as the area where drilling was located closer to the coast than the region where the sources are. This ion relative Cl^-/ Na^+ is just above 1.8 in the dry season for some sources and wells. It is found that, just as the majority ions (Ca^{2+}, Mg^{2+}, Na^+ and HCO_3^- accidental ions such as (NO_3^-, Cl^-, SO_4^{2-}), also have an influence on the mineralization of the water.

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