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ORIGINAL ARTICLE

Hydrogeochemical Characterization of Continental Intercalary, Terminal, the base and the Korama Aquifers Groundwater found in five Local Governments in the Zinder region in the Republic of Niger

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ABSTRACT
This work deals with the hydrogeochemical characterization of the Korama, the Continental Intercalary ,Terminal and base aquifers groundwater, found in the local governments of Mirriah Tanout Kantché, Gouré and Magaria in Zinder region in the Republic of Niger, West Africa. For that thirty (30) sampling points identified by GPS coordinates were sampled in the periods from November to December 2013 and June-July 2014. In order to determine the status of these waters during these times their facies were established on the basis of data previously calculated. Four types of facies characterize the waters of these aquifers: the calcium chloride-type facies representing 10%, located in continental infill, and terminal in the Manga, the sodium chloride-type facies located at continental, intermediate terminal Plinth and they represent 16.67% those of calcium bicarbonate type are the most abundant with 50% and meet in four types of aquifers i.e. the Korama, the continental infill, the continental terminal and the base and the Sodium bicarbonate type facies representing 23.33% all located in the continental infill. This mineralization is mainly due to the dissolution of minerals, anthropogenic contribution and exchange of water between aquifers.
Keywords: *hydrogeochemical characterization, aquifers, mineralization, Zinder region.*

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INTRODUCTION

Water is a scarce resource [1], which is common to all humanity. [2] This resource is unevenly distributed throughout the world. [3] The largest liquid fresh water reserve of the planet consists of groundwater with about 8 to 10 million km3, representing 98 and 99% of these waters. [4] Groundwater is in Niger, particularly in the Zinder region the main source of drinking water. [5] In Niger characterization studies are old and sometimes non-existent to this is added the lack of regular monitoring of the evolution of the water quality of these [6] aquifers. This article discusses the hydrogeochemical characterization of groundwater aquifers found in four of the five local governments in the Zinder region in the Republic of Niger

MATERIALS AND METHODS

For purposes of the study we selected thirty (30) sampling points that already exist in the region. These points are divided into two types: human cemented wells and boreholes motor equipped with a mini drinking water supply (FWS).

The samples of water intended for physicochemical analyzes were conducted according to the rules described by L-BARES [7]. A purge of one to two minutes is observed on these structures, since they are in continuous operation prior to their sampling.

Physical, physico-chemical and chemical parameters that were subject of investigation in our study, are

analyzed in the laboratory of the Zinder Regional Directorate of Water and Sanitation (ZRDWS)
Physical parameters such as electrical conductivity; the temperature and pH are measured in situ by potentiometry and / or electrometry with a Wagtech WE 30200 and a Wagtech WE 30210 conductivitymeter. Cations such as sodium, potassium are analyzed by a Jenway PFP7 flame photometer, the total calcium, magnesium hardness; carbonates and bicarbonates are measured by the digital tetrameter and calcium and magnesium ions are deduced by simple calculation.
In the end colorimetry allows the determination of anions such as sulfate, nitrates, chlorides, fluorides, nitrites ions and the total iron from the DR 2800 spectrophotometer. The diagram software (Roland SIMLER Hydrology Laboratory of Avignon) and Microsoft excel enabled: to make the Piper diagrams, determine the hydrochemical facies of waters and the mineral saturation indices. The Arc View 3.2 software helped to perform the geological and hydrogeological maps. The Microsoft excel software was used to perform linear binary diagrams that allowed by simple correlation between major elements determine the processes at the origin of the mineralization of the waters.

RESULTS

Representations of piper in different aquifers give us the following results:

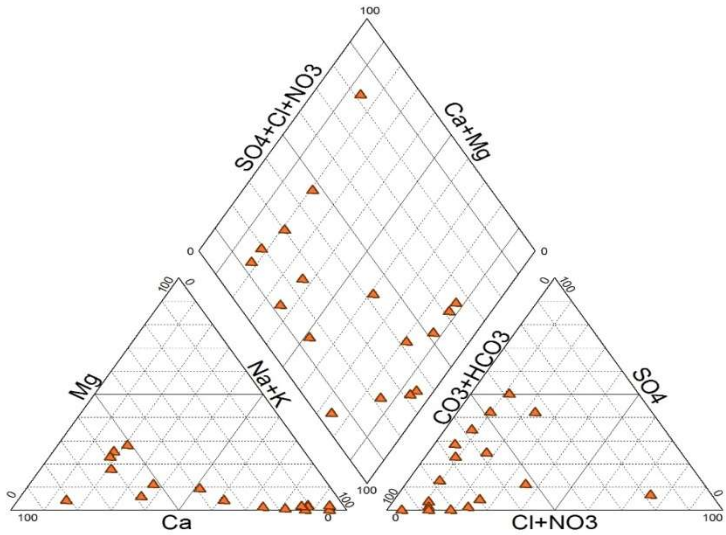

Figure 1: Different types of facies met at the Continental Intercalary

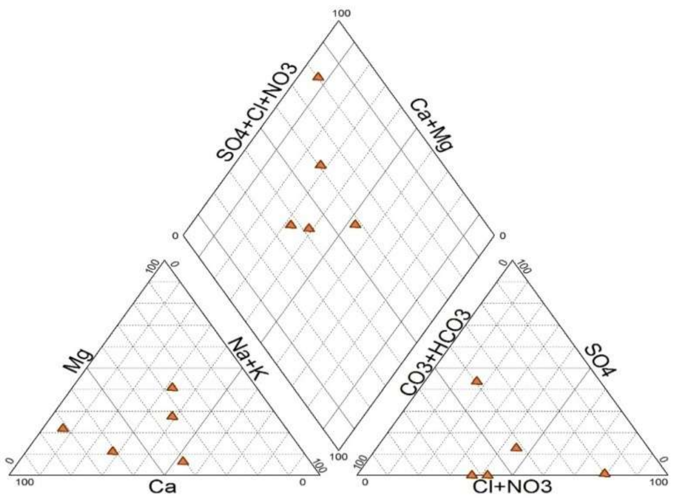

Figure 2: Different types of facies met at the Continental Terminal

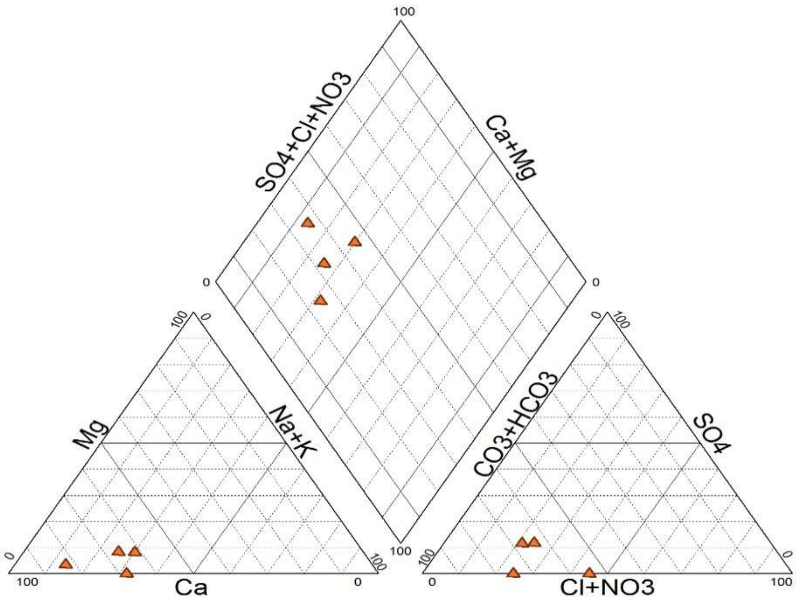

Figure 3: Different types of facies met at the Korama

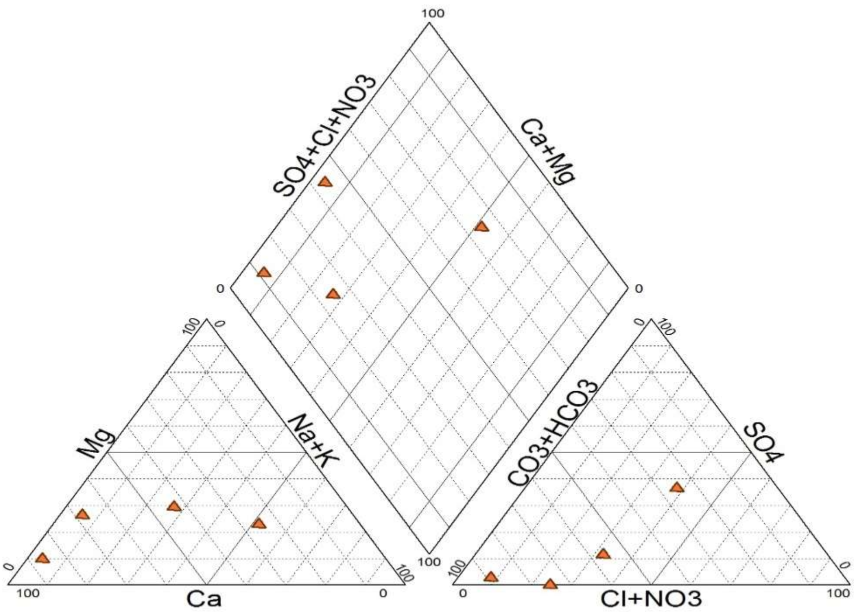

Figure 4: Different types of facies met at the Base

In the tables below follow the results of physical chemical and physicochemical tests,

Table I: Average parameters analyzed on the structures from 2013 to 2014

NAMES	pH	T°	conductivity	FeT	Cl^-	F^-	NO_2^-
Garagoumsa	7.1	31.8	355	0.02	1.8	2.74	0.0132
Diota Haoussa	7.79	31.2	189	0.01	1.6	1.92	0.0693
Koundoumaoua	7.17	30.4	345	0.19	3	4.76	0.079

Daouché	**5.95**	**30.4**	**44**	**0.02**	**2.2**	**0**	**0.075**
Zongo Algabit	**7.25**	**32.6**	**156**	**0.14**	**11.6**	**0**	**0.036**
Belbedji	**8.67**	**33.2**	**390**	**0.004**	**14.4**	**4.48**	**0.033**
Takiéta	**6.59**	**31.9**	**188**	**0.11**	**6.16**	**0.15**	**0.085**
Toudoun Agouwa	**6.38**	**31.7**	**107**	**0.39**	**6.6**	**0.3**	**0.052**
Dakouma Didiari	**6.18**	**31.1**	**174**	**0.05**	**14.4**	**0.16**	**0.066**
Dan Amanta	**7.46**	**32.5**	**1209**	**0.07**	**417**	**0.21**	**0.056**
Kelle	**6.51**	**32.1**	**204**	**0.02**	**10**	**0.15**	**0.066**
Gangara	**8.94**	**38.2**	**337**	**0.03**	**3.6**	**1.22**	**0.013**
Samia	**8.92**	**33.4**	**274**	**0.02**	**6.8**	**0.23**	**0.119**
Sabon Kafi	**8.94**	**38.6**	**457**	**0.1**	**11.6**	**0.99**	**0.039**
Yagagi	**9.06**	**33.5**	**279**	**0.07**	**6.4**	**0.21**	**0.026**
Bakin Birji	**7.23**	**32.6**	**166**	**0**	**5.9**	**0.35**	**0.099**
Ollellewa	**8.54**	**37.7**	**221**	**0.02**	**1.6**	**0**	**0.082**
Yaouri	**4.83**	**29.1**	**22**	**0.01**	**4.2**	**0**	**0.0858**
Kourni Koutchika	**4.93**	**31.2**	**34**	**0.03**	**4**	**0**	**0.066**
Sassoumbroum	**5.09**	**32.5**	**13**	**0.02**	**3.2**	**0.27**	**0**
Yékoua	**5.74**	**32.1**	**804**	**0.04**	**8.6**	**0.19**	**0.033**
Yari	**7.32**	**33.3**	**358**	**0.15**	**9.8**	**0.25**	**0.059**
Katofou	**4.91**	**31.7**	**46**	**0.03**	**4.6**	**0**	**0.0726**
Gomba	**5.85**	**31.4**	**35**	**0.02**	**2.6**	**0**	**0.0891**
Guidimouni	**6.34**	**31.4**	**72**	**0.04**	**5.6**	**0.21**	**0.016**
Dungass	**6.42**	**31.4**	**83**	**0.01**	**2**	**0.05**	**0.013**
Guéza Mahaman	**7.44**	**34.2**	**465**	**0.02**	**7.5**	**0.33**	**0.0462**
Dan Ladi	**7.1**	**33.3**	**1507**	**0.01**	**68.6**	**0**	**0056**
Birni Kazoé	**7.42**	**33.2**	**2170**	**0**	**116.4**	**2.82**	**0.924**
Gouna	**7.42**	**32**	**130**	**0.05**	**4.4**	**0.23**	**0.053**

Table I (continued)

NAMES	**NO_3^-**	**SO_4^{2-}**	**HCO_3^-**	**Na^+**	**K^+**	**Ca^{2+}**	**Mg^{2+}**
Garagoumsa	**8.36**	**38**	**55**	**26.8**	**19.8**	**4**	**0.486**
Diota Haoussa	**8.8**	**3**	**92**	**17.6**	**5**	**13.6**	**1.944**
Koundoumaoua	**3.52**	**29**	**61**	**16.8**	**16**	**12.8**	**0.972**
Daouché	**3.52**	**1**	**19.8**	**0.6**	**2.75**	**5.6**	**0.972**
Zongo Algabit	**1.76**	**31**	**32.7**	**28**	**2.75**	**3.2**	**0.243**
Belbedji	**4.4**	**32**	**95.5**	**60**	**0.6**	**11.6**	**0.243**
Takiéta	**1.76**	**1**	**90.28**	**5**	**5**	**21.6**	**5.832**
Toudoun Agouwa	**0.44**	**0**	**50**	**1.75**	**3.32**	**10.4**	**2.43**
Dakouma Didiari	**0.36**	**1**	**80**	**8.5**	**6.65**	**15.2**	**1.944**
Dan Amanta	**35.2**	**50**	**183**	**18.2**	**14.5**	**130.4**	**3.888**
Kelle	**24.2**	**10**	**61**	**5**	**6.65**	**19.2**	**6.318**
Gangara	**3.52**	**34**	**100.2**	**49.5**	**1.6**	**2.4**	**0**
Samia	**2.2**	**27**	**103**	**49.5**	**0.6**	**2**	**0.486**
Sabon Kafi	**5.72**	**88**	**86**	**68.6**	**0.6**	**8.48**	**0**
Yagagi	**5.28**	**17**	**131.5**	**49.5**	**0.6**	**6.44**	**0.486**

Bakin Birji	**3.52**	**0**	**95**	**11.75**	**4**	**19.84**	**1.215**
Ollellewa	**2.2**	**0**	**102.6**	**28.6**	**0.6**	**8.24**	**0.243**
Yaouri	**7.04**	**0**	**19.5**	**4.9**	**0.6**	**4**	**1.944**
Kourni Koutchika	**7.48**	**0**	**24.2**	**4**	**0.6**	**3.2**	**2.916**
Sassoumbroum	**3.52**	**2**	**8.4**	**3.5**	**0.6**	**2.6**	**0.243**
Yékoua	**188.32**	**2**	**63.14**	**6.75**	**3.32**	**82.4**	**15**
Yari	**5.72**	**46**	**53**	**8.75**	**5**	**22.4**	**2.43**
Katofou	**7.04**	**0**	**18**	**3**	**0.6**	**6**	**0.484**
Gomba	**0.44**	**0**	**15**	**1.8**	**0.8**	**4.2**	**0**
Guidimouni	**8.8**	**7**	**48**	**2.5**	**2**	**19.2**	**0.486**
Dungass	**3.52**	**3**	**22**	**2.5**	**0.6**	**6.4**	**0.486**
Guéza Mahaman	**11.14**	**6**	**248**	**3**	**5**	**62.4**	**14.58**
Dan Ladi	**129.8**	**69**	**429.62**	**8.5**	**6.65**	**236**	**16.038**
Birni Kazoé	**264**	**345**	**305**	**52.8**	**5.5**	**24**	**13.22**
Gouna	**11.88**	**0**	**59.17**	**7.5**	**1.33**	**11.6**	**4.73**

Figures 5, 6, 7 and 8 below show the variation of Ca_2^+ions according to the HCO_3^-ions and varying the ratio Mg / Ca based on the F- ions respectively in the waters of the Continental Intercalary, Continental Terminal , the Korama and the base.

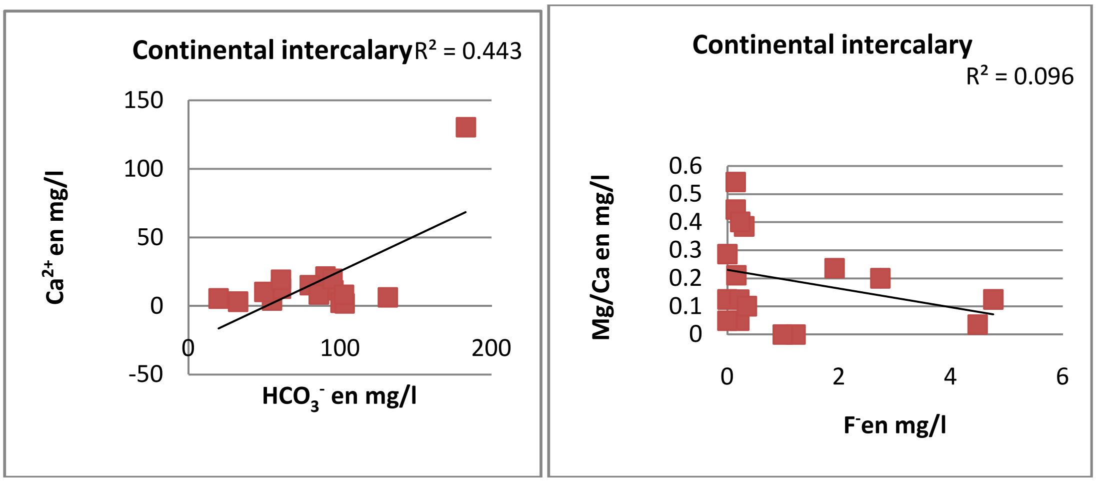

Figure 5 : Variation at the Continental Intercalary

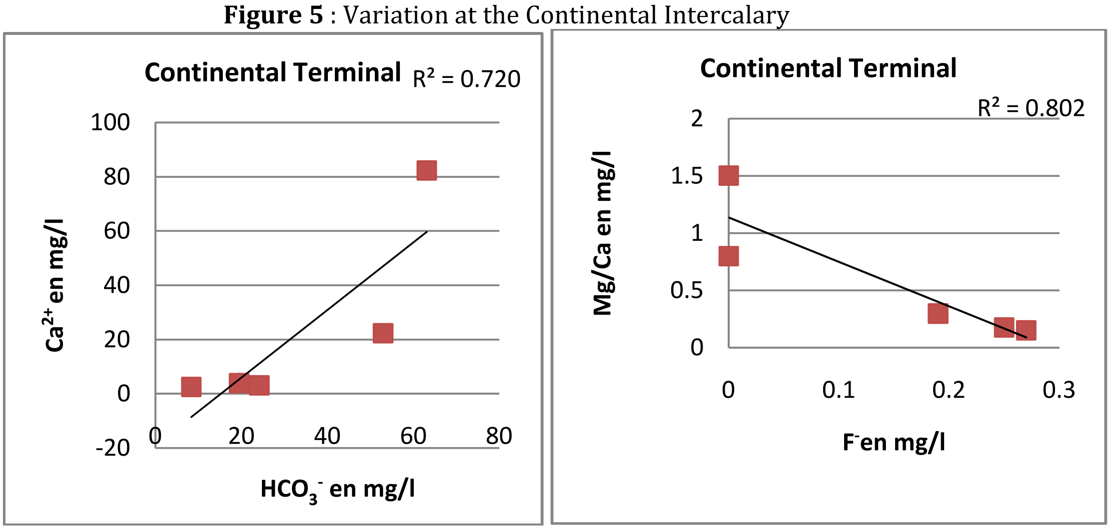

Figure 6: Variation at the Continental Terminal

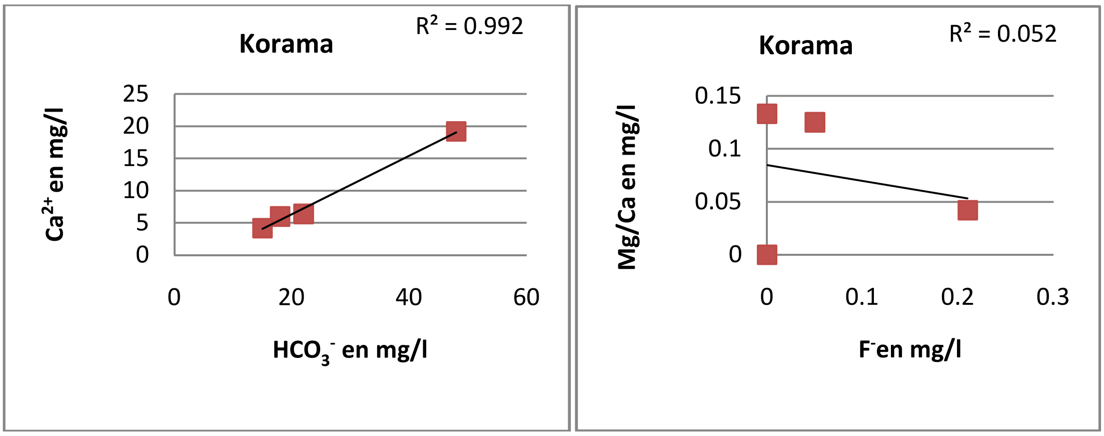

Figure 7: Variation at the Korama

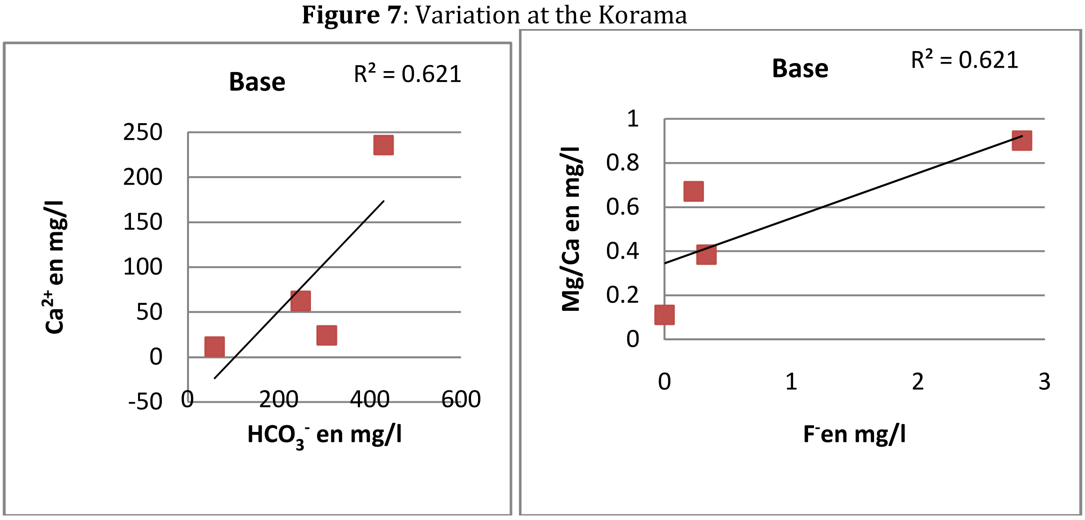

Figure 8: Variation at the Base

DISCUSSIONS

The analysis of the piper diagram of all structures (Figures 1, 2, 3 and 4) reveals four types of facies that characterize the waters of these aquifers: the calcium chloride-type facies, sodium chloride type facies , bicarbonate calcium type facies and sodium bicarbonate type facies. The presence of these facies in the study area was reported by Rabe and Sandao [8, 9].Sodium bicarbonate types of facies (7) in number are all located in the continental infill. The other three types are divided into three to four aquifers, reflecting the importance of hydro-geochemical processes that control the mineralization of these waters. [10] However the structures fifteen (15) in number with calcium bicarbonate type facies are the most abundant.

In the Korama aquifer, the presence of calcium bicarbonate facies is related to the presence of [11] gypsum in the table water, but also depending by the sector, the aquifer wall recent sands of the Korama is constituted either by calcareous sandstone of the Continental Intercalary, or the Precambrian basement. [9] In these waters the conductivity values are between 35 and 83µS/cm, it concerns a slightly mineralized water [12, 13]. The pH are between 4,91et 6.42 pH units, are acidic.

In the Continental Intercalary and terminal aquifers the calcium bicarbonate facies is related to the dissolution of minerals such as gypsum and limestone present in these aquifers. [11] Continental Terminal in the correlation coefficient between fluoride ions and Mg / Ca is good (Figure 6) which means that there is a relationship between the presence of dolomite and the presence offluorspar [14] solutionization of these minerals is to cause of this type of facies and high levels of fluoride ions and calcium). In these waters the conductivity values are between 13 and 804 µS/cm, it is about water with a mineralization ranges from very low to very strong [12, 13]. The pH, between 5.74 4,83et pH units, is acidic.

In the aquifer base, the conductivity values are between 130 and 2170 µS/cm, it concerns a moderately to excessively mineralized water [12, 13]. The pH is between7.1 and 7.44 pH units, are neutral to slightly basic. In these waters the correlation coefficient between fluoride ions and Mg / Ca is quite good (figure: 8) as is the case for example of the aquifer of the Carboniferous of the Moscow basin [15] or for the Paleocene water table in Senegal [16, 17, 18] Thus there is a relationship between the presence of dolomite and the presence of fluorspar [14]. Thus the presence of water with calcium bicarbonate facies is due to the dissolution of dolomite, but also by the arrival of continental infill waters which is a table water that uncomfortably overlies the base [9] through multiple cracks of the latter. The high levels of fluoride ions are linked to the dissolution of fluorspar.

In the Continental Intercalary aquifer facies sodium bicarbonate is related to the presence of a reservoir layer which is made of calcareous sandstone [19] and sodium chloride salt [11]. The relatively high levels of chloride ions, sodium and calcium confirm the setting solution of those minerals. In these waters the conductivity values are between 44 and 1209 µS/cm, it concerns water with a mineralization ranges from very low to excessively [12, 13]. The pH between 5.95 and 9.06 pH units varies from slightly acid to alkaline.

In the Continental Intercalary and terminal aquifers the presence of Calcium chloride facies is related to minerals such as gypsum and sodium chloride salt present in these aquifers [11]. In Continental Intercalary and Terminal aquifers the sodium chloride facies is related to the presence of sodium chloride salt and silty fraction. The silty fraction comprises minerals such as illite and chlorite. [20] The relatively high levels of chloride and sodium ions are observed, confirming the dissolution of the ions from these deposits [10].

The base aquifer being neither consisting of salt or silty fraction, the presence of sodium chloride-water facies is related to the flow of water exchange with the Continental Intercalary and Terminal aquifer by natural leakage through multiple fractures of the base [9].The total iron contents observed in the Continental Intercalary and Terminal, come from the dissolution of the oolitic laterite iron [11], ferruginous sandstone [21] and siderolithic sandstone [9].

The base formations are covered in the Southern part by sedimentary series and sandy covering deposits up to the height of the line Matamey - Bande. Following this line, the base formations rise to reappear along the border of Nigeria and around the city of Zinder. In the part where the base is flushed with the waters of the Continental Intercalary and terminal receive high levels of fluoride ions from granitoids and metamorphic formations of the base through its cracks and fractures [9].

Changes in HCO_3^-ions based on CO_2 + in the waters of the base, the Continental Terminal and the Korama (Figures 6, 7 and 8) show that these parameters can have the same origin. Bicarbonate ions are largely derived from the CO_2 dissolution in water according to the following equations [10]:

$$CO_2+H_2O \leftrightarrow H_2CO_3$$

$$H_2CO_3 \leftrightarrow H^+ + HCO_3^- \quad K_{H2CO3}=10^{-6,35}$$

$$HCO_3^- \leftrightarrow H^+ + CO_3^{2-} \quad K_{HCO3^-}=10^{-10,25}$$

these ions mainly originate from the dissolution of inorganic carbonates whose presence is demonstrated in the [11] area.

The calcium source can be related to the dissolution of gypsum whose presence is demonstrated in the [11] area. This dissolution would also be cause the presence of sulfate ions. The high levels or contents of nitrate (264 mg / l) are observed in the aquifer base and the Continental Terminal (Table I), may be related to the infiltration of waste water from the watering of livestock spaces located around these structures or irrigable areas, through fractures that contains the base [9], only in this area the fertilizer are weakly used, suggesting the presence of organic matter in these aquifers but also by direct introduction of water following the rainy season floods, cemented wells in human motor.

CONCLUSION

Aquifers of the Korama, the Continental Intercalary, Terminal, and base are the main sources of drinking water that are exploited in the Zinder region.

Relatively high concentrations of parameters such as chloride, fluoride, nitrate, sulfate, bicarbonate and calcium were observed. These concentrations are related to the dissolution of minerals, the exchange of water between the different layers across multiple invoices and crack the base and anthropogenic inputs from the surface in areas where the base is flushed. We distinguish four types of facies: those of calcium chloride-type, sodium chloride-type of calcium bicarbonate type and sodium bicarbonate type. Sodium bicarbonate type facies are all located in the continental infill. The three other types of facies are divided into three to four aquifers, reflecting the importance of hydro-geochemical processes that control the mineralization of these waters.

This mineralization is mainly due to the dissolution of minerals, anthropogenic contribution and exchange of water between aquifers.

REFERENCES

1. LACOSTE Y. (2003). Water in the world battle for life, Larousse, Paris.
2. V. SHIVA (2003). The water war, Paragon: L'Aventurine, Paris.
3. S. PAQUEROT, Water: a private or public health in the Americas, [http://www.iqhei.ulaval.ca/Pdf /ORIEPaquerot.pdf] (accessed June 6, 2005)
4. MARGAT (2008). Operations and uses of groundwater in the world. Imta.janium.net. Co-published by UNESCO and BRGM.
5. Derwich E, L Benaabidate, Zian A, O Sadki, Belghity D (2010). Physico-chemical characterization of water from the alluvial aquifer top Sebou downstream from its confluence with Oued Fes. Larhyss J., 08, pp101-112.
6. [6] Oga M.-S., Lasm T. Yao TK, N. Soro, Saley MB, D. Kouassi, Gnamba F. (2009). Chemical Characterization Des Eaux aquifers Fracture: Case De La Region De Tiassalé In Cote D'ivoire.
7. The BAR (1993). Sampling Handbook groundwater BRGM National Geological Service, Department C3G, France.
8. Rabé S (2010) inorder complementary study of the evaluation of the quality of groundwater in the region of Zinder, Final Report, PASEHA 104 Niger 814, 44 pages.
9. Sandao I. (2013). Studies Hydrodynamics, hydrochemical and Isotopic Groundwater Watershed Korama / South Zinder, Niger: Impacts of climate variability and human activities. PhD Thesis, University Abdou Moumouni, Niamey.
10. Issa S. (2012). Water hydrogeochemical characterization Underground near the uranium mine operated by the Corporation of Mines of the Air in Arlit in Niger. Master Thesis, University of Abomey, Cotonou.
11. GREIGERT J (1978). Groundwater Atlas of the Republic of Niger. State
12. Knowledge, BRGM report AGE001 79, Orleans, France.
13. J.RODIER (1984). The analysis of the water. (Book) Dunod Paris
14. J.RODIER; B. Legube; N.Merlet et al (2009). The Water Analysis, 9th edition, Dunod, Paris.
15. Malcuit E. (2012). Origin of mineralization of water in a deep aquifer multilayer: Example of the mineralized zone of Entre-Deux-Mers (Aquitaine Basin, France). PhD Thesis, University Michel de Montaigne -Bordeaux ENSEGID 3-IPB, Bordeaux.
16. Limantseva O.A; Ryzhenko B.N; E.V Cherkasova (2006). Model for formation of fluorite-bearing rocks in the carboniferous deposits of the Moscow artesian basin. Geochemistry International, 2007, 45, 9, pp. 900-917.
17. Travi Y (1983). Fluoride in natural waters in Senegal. Precise delimitation of areas with fluorotic risks. International Symposium A.U.P.E.L.F. UNESCO, Thies, in April 1983, 15p.
18. Travi Y (1984). Origin of high fluoride levels in groundwater in the table pléocène the region Mbour, Senegal: the role of the magnesium ion. CR. Acad. Sc. Paris, t.298, Series 11, 7, pp. 313-316.
19. Travi Y (1988). Hydrogeochemistry fluorine isotope hydrology and aquifers of the Senegal River Basin. Origin and fluorine transport conditions in groundwater. PhD Thesis es-Sciences-University Paris Sud, Orsey Centre 196p.
20. Konaté M Denis M, Yahaya M, M Guiraud (2007). Ettranstensive extensive structuring the Devonian-dinantiendu bassinde timmersoï (Western edge of the Air, NordNiger). J. Annals. Univ. Ouaga. Series C 005, 1-32.
21. Mr. Maanan (2003). Sedimentological study of the filling of the lagoon of Sidi Moussa (Morocco's Atlantic coast) particle size characterization, mineralogical and geochemical. PhD Thesis, University Chouaib Doukkali Morocco.
22. Sandao I. (2010) Contribution to the knowledge of the current state of water resources dubassin of Korama: South of Zinder Region, DEA, University of Niamey (2010) 96 pages.

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