ACTA SCIENTIFIC AGRICULTURE (ISSN: 2581-365X)

Volume 3 Issue 6 June 2019

Research Article

Ground Water Quality Characterization in the South of Algeria (Tindouf Region) - In Excess Fluorine

N Nabbou[1,2]*, M Belhachemi[1], T Merzougui[3,4], Y Harek[2], I Mokadam[1,3] and SB Nasri[4]

[1]*Chemistry and environmental sciences Laboratory, University TAHRI Mohammed Bechar, Algeria*

[2]*Inorganic and Environmental Chemistry Research Laboratory, University Aboubekr BELKAID Tlemcen, Algeria*

[3]*Faculty of Technology, Department of Hydraulics, University TAHRI Mohammed Bechar, Algeria*

[4]*ANRH Laboratory, Algeria*

***Corresponding Author:** N Nabbou, Chemistry and environmental sciences Laboratory. University TAHRI Mohammed Bechar, Algeria and Inorganic and Environmental Chemistry Research Laboratory, University Aboubekr BELKAID Tlemcen, Algeria.

Received: January 16, 2019; **Published:** May 06, 2019

DOI: 10.31080/ASAG.2019.03.0463

Abstract

The objective of this study is to give an outline on the subsoil water quality of the area Tindouf, more particularly fluoride. We started a subsoil water sampling campaign in these areas and the test sample selection of water touched all the aquiferous levels. The analyses results are found 74% bore wells waters exceed permissible limit cited in Algerian standards and WHO standards. The fluoride concentration varied from 0.16 to 3.31 μg. cm-3 in upper Ordovician, Westphalian complex – Tertiary, upper Visean and Continental Tertiary aquifer. The geochemical trend of groundwater in the study area demonstrates that sodium is the dominant cation (Na+ > Ca^{+2} > Mg^{+2} > K+) and sulphate is the dominant anion (SO_4^{-2} > Cl- > HCO_3- > NO_3- > F-). We tried to better reveal the evolution of the fluoride concentrations by their presentation in content fluoride map.

Keywords: Groundwater; Fluoride; Tindouf Region; Water Quality; Hydrochemical Facies; Contamination

Introduction

Water is a prime need for human survival and industrial development. It is a necessary richness for all human activities. Groundwater quality is very essential in a sense of practical utility for domestic, agricultural and industrial purposes and plays significant role in the living organism that existing in this world water [1-3].

The quality of groundwater depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. Ground water occurs in weathered portion, along the joints and fractures of the rocks. In fact, industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution of surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of heavy metal in excess. The situation gets worsened during the summer season due to water scarcity andrain water discharge [4-7].

Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems [8,9]. The fluoride is to scale planetary one the polluted them of geological origin more frequently met in ground waters [4,10]. Fluoride containing minerals exist naturally in the earth's crust causing soluble fluoride salts to continuously enter into groundwater. It is well known that water containing fluoride ions at low concentration of about 1 μg. cm-3 have beneficial effects on teeth by preventing and reducing tooth decay [11]. However, drinking water with high concentration of fluoride ions causes dental and skeletal fluorosis as well as osteoporosis [12]. The fluoride Concentrations encountered in main aquifers in northern Algerian Sahara frequently exceed WHO standards, And reach in majority 3 mg/l. This is the origin of lesion disorders or functional reaching dental bone system (endemic fluorosis), especially in the eastern part of the Sahara Northern [13]. Considering this factor and keeping an account of the importance of public health, this study was designed to understand the status of fluoride in groundwater of a part of western Algerian Sahara, Tindouf region. The physico-chemical parameters of the taken water samples are determined in collaboration with the Adrar ANRH laboratory (Water Resources National Agency laboratory).

Materials and Methods

Study area

Geography

Tindouf is a province which covers an area of approximately 159,000 km^2, is located in the southwest of Algeria, in the far west of the desert region Saoura, south of Hamada, between the meridians 5° - 9° W; and the parallels 26° - 28° North. It is limited to the north by Morocco border, northeast by the Bechar province, west by the non-autonomous territory of Western Sahara, to the east by the Adrar province and south by Mauritania (Figure 1). Its population is estimated in 2010 to 59 898 inhabitants [14,15].

Figure 1: Location of Tindouf region.

Tindouf area is part of the desert climate zones, characterized by an annual air temperature of 24°C that ranges from 45ºC in July to 5ºC in January. The regional rainfall is unevenly distributed throughout the area and varies seasonally with an average of 50 mm/year. Due to the evaporation rates and high infiltration and the flat topography of the region, can be clearly define a water drainage system. Natural discharge of water occurs mostly topographical levels lowest in the wadis and sebkhas. From the morphological point of view, the province territory consists vast stretches flat and monotonous (Hamada), with the exception of some residual reliefs (-50m elevation). The river system is characterized by large wadis (O. El Ma, O. Sobti, O. Tartrat, O. Menkrines, etc...) which often remain dry throughout the year. They turn into veritable torrents after heavy rainfall characteristics of desert regions [16,17].

Geology

Tindouf basin is a vast synclinal axis roughly oriented East – West. The heart of the syncline is occupied by deposits of the Mio - Pliocene (Hamada) based on Paleozoic formations (Carboniferous, Devonian, Silurian, Ordovician and Cambrian). In the South and South East part of the Tindouf territory consists of volcanic and metamorphic rocks of the Massif Yetti – Eglab [13,15]. Stratigraphically, the difference formations are represented in Figure 2 and 3.

- **Precambrian**: It is represented by a crystalline (granite) and a metamorphic (metamorphic rock) basement.
- **Infracambrian**: It is composed of sandstone, limestone, dolomite and clay and divided into three parts
- **Lower detrital group**: almost exclusively sandy or clayey sandstone.
- **Carbonated Complex:** In this complex, there's clear dominance of limestone, dolomite and quartz. Its power ranges from 600 (in the West) to a few dozen meters (east), even thinner to the north (27 ° N).
- **Higher detrital Group**: It is constituted by a powerful set of clays. This group certainly exceeds 1000 m in the syncline Chenachane.
- **Cambrian:** It is unconformably on Infracambrian. It is explored by a few oil drillings in the northern part of the Tindouf basin with gréso-quartzite facies. These marine formations are thin (maximum 40 m south of Gara Djebilet). It is thicker than 1000 m North.
- **Ordovician:** It is constituted by Aouinet Legraa sand stones resting on the base, thicker in the East (120 m). It is subdivided into two parts:
- **Devonian:** It is more fossil than previous systems. Its average thickness is 1300 m. it is represented by the following formations:

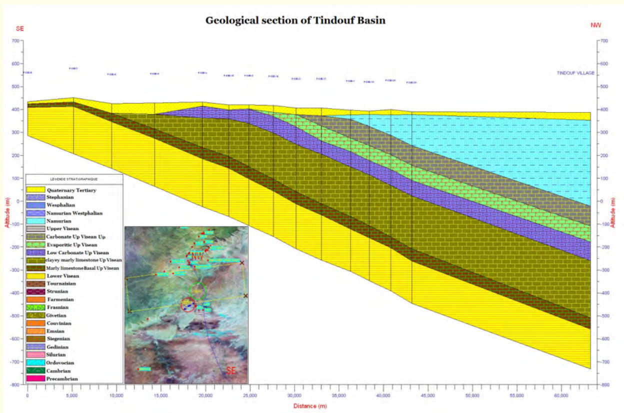

Figure 2: Geological section of Tindouf Basin.

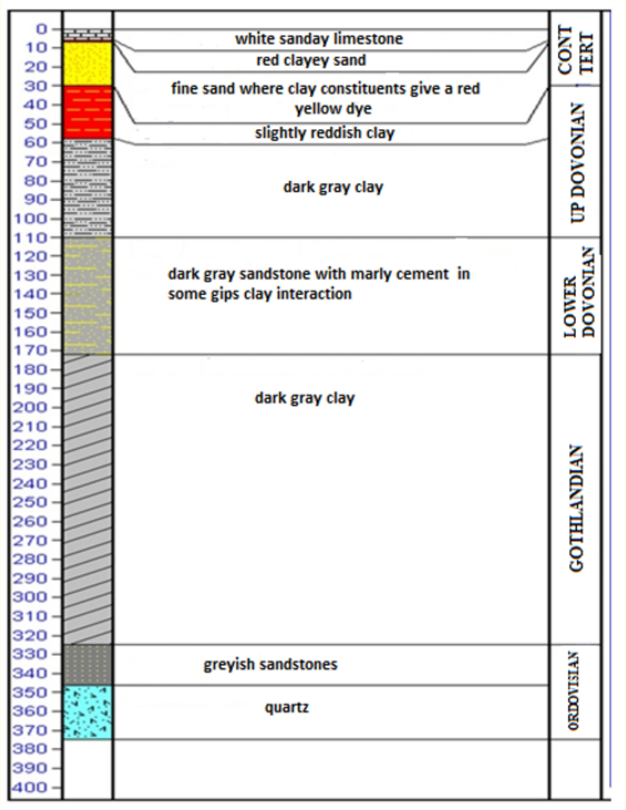

Figure 3: Schematic cross-section of geology in Tindouf.

Tertiary (hamadian series)

This is a continental facies constituting the Hamada represented by a sandy and clayey sandstone lithology. The roof of the Hamada consists by tabular lime stone strongly silicified with tuffeuses slabs of lacustrine origin.

Quaternary

Quaternary clastic deposits are represented by alluvial formations, filling wad is and aeolian sands on the ergs.Alluvium consist of detritus from pelitic rock debris down, absolutely not rated fashioned and very little. The aeolian sands are quartz-feldspar, the fraction is composed of fine-grained, yet accompanied by a very small amount of pelitic fraction [16-18].

Methodology and sampling analysis

The analysis of water chemistry is an essential supplement to the hydrogeological study of groundwater and therefore the management of water resources. It allows providing extensive information on the aquifer, the nature of the banking, power and circulation areas, and the potability of the water. To achieve these objectives we conducted an inventory of water points of the province, located water points by GPS and take samples for physico-chemical analyzes and the determination of fluorine content.

Our study focused on 56 collective bore wells distributed over four aquifers (upper Ordovician, Westphalian complex – Tertiary, upper Visean and Continental Tertiary aquifer). The reasons for the choice of groundwater are based on the importance of human exploitation of these two layers in the study region and the risk factors such as water pollution: the lack of sewerage system (use of pit latrines as excreta disposal system), lack of drinking water network, the location near of agricultural land, the situation close to the uncontrolled landfill and the geographical location of different points of the samples is determined by their geographical coordinates using a GPS (Global Positioning System) etrex SUMMIT GARMIN type. Groundwater sampling was carried out once in month from December 2011 to March 2017 in Tindouf area.

The samples were filled in the polyethylene bottles (1500 ml) washed with distilled water and rinsed with the sample before collection. Methods of collection and analysis for groundwater samples were essentially based on the guideline of the Standard Method of Analysis [19]. pH and EC were measured at the point of collection using portable conductimeter such as Consort (C5010). In the ANRH Adrar laboratory, Major cations of Na, K and Ca were determined by flame spectrophotometer (JENWAY CLINICAL PFP7). Major anions of NO_3, NO_2 and SO_4 were analyzed by colorimetry with an UV visible spectrophotometer (SHIMADZU. UV-1700 PharmaSpec). Chloride was estimated by $AgNO_3$ and TH were determined titrimetrically using standard EDTA. Mg was calculated as follows: TH= TMg^{+2} + TCa^{+2}. Fluoride concentration was determined using the emission spectrometry inductively coupled plasma (ICP-AES).

Results and Discussion

Physico-chemical analysis

The fluoride concentration in fifty six (56) bore wells waters of Tindouf area varies between 0.16 and 3.31 µg. cm-3 (Table1) in upper Ordovician, Westphalian complex – Tertiary, upper Visean and Continental Tertiary aquifer. from this result, the boreholes water obtained from the study area have been classified into four groups as low (0.1 to 0.5 µg. cm-3) 6% of bore well waters, medium (0.5 to 1.5 µg. cm-3) 20% of bore well waters, high (1.5 to 2 µg. cm-3) 38% of bore well waters, and very high (2 to 4 µg. cm-3) 36% of bore well waters, the four groups are represented in fluoride content map (Figure 4). These ground waters are destined to the drinking waters. The fifty six (56) bore wells waters are located in Tindouf city and Oum El Assel.

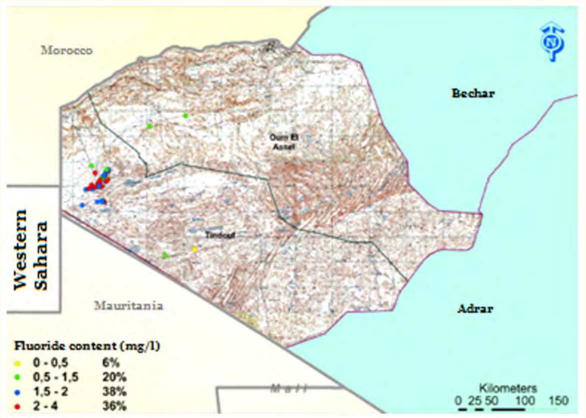

Figure 4: Fluoride content map of Tindouf city.

High fluoride groundwater leads a health threat to millions of people around the world. Fluoride is a key aspect of water quality in rural water supply system, which potentially affects the sustainability of water if it exceeds its prescribed limit. The fluoride content in the groundwater is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, temperature, pH, concentration of calcium and bicarbonate ions in water, etc [20]. Fluoride could have originated from fluoride bearing minerals such as fluorite in the rocks. Apambire., *et al*. (1997) have suggested that the main source of groundwater fluoride in granitic rocks is the dissolution and anion exchange with micaceous minerals and their clay products. However, drinking water with high concentration of fluoride ions causes dental and skeletal fluorosis as well as osteoporosis [6,12].

The pH depends on the source of water; the geological nature of substrate and the watershed have been through [21]. This parameter determines a large number of physico-chemical equilibrium between water, the dissolved carbon gas, carbonates and bicarbonates which are buffered solutions giving aquatic life favorable development. In most natural waters, the pH is usually between 6 and 8.5, whereas in the warm water, this latter being between 5 and 9 [22]. In the case of the study area, the values of water pH do not show variations outstanding, with a minimum of 6.15 and a maximum of 7.77 which reflects a slight alkalinity of the medium. These values are acceptable range of pH for drinking water in WHO and Algerian standards [23,24]. The conductivity gives an idea of the mineralization of water and is a good marker of water origin. Actually, the conductivity measurement used to evaluate the amount of salt dissolved in water, thus its mineralization. The electrical conductivity depends on the loads of endogenous and exogenous organic material, making salts after decomposition and mineralization and also with the evaporation phenomenon which concentrates these salts in water, it also varies according to the geological substrate done [25,26]. Groundwater always has higher EC levels when compared with surface water [10]. Electrical conductivity values varied between 1.08 – 4.34 mS/cm in all study sites (Table 1).

Calcium and magnesium salts contained in water produce the total hardness. There are: a carbonate hardness that matches the content of carbonates and bicarbonates of Ca and Mg and a non-carbonate hardness produced by other salts. It is mainly the contact of groundwater with the rock formations: The drift calcium attack of dissolved CO_2 from limestone (dolomite) or dissolved as sulfate in gypsum. The natural water hardness depends by the geological structure of the soil traversed [21,22,26]. Range of TH in the groundwater samples was 43 –101°F (Table1), this parameter is varied from one drilling to the other would be linked to the lithology of the geological formation of aquifers and in particular to its composition of magnesium and calcium.

Nitrates are present in the water by leaching of nitrogen compounds in the soil by decomposing organic matter or synthetic or natural fertilizer. Azote is an indispensable element in construction of cellule. In the aquatic environment, nitrogen exists in molecular form (N_2) or ionized: Nitrate (NO_3), Nitrite (NO_2) and ammonium (NH_4+) and dissolved or particulate organic form (protein, amino acids, urea, etc.). These different forms of nitrogen are constantly changing. They pass from one to the other by physic-chemical and especially biochemical process. Nitrates are only one of many forms of nitrogen in water, while providing generally the most abundant form of mineral nitrogen [27]. The nitrate is highest in 90% groundwater samples of Tindouf. It varies from 3.2 to 120 µg. cm^{-3} and exceeds also the permissible limit cited in Algerian and WHO standards [23,24] (Table 1).

The evolution of the Mg/Ca ratio is locally indicates the intervention of gypsum in the enrichment of calcium and magnesium groundwater [25]. Calcium concentration ranged between 45 to 202 µg. cm^{-3} and found within the prescribed limit. Magnesium content in the investigated groundwater samples is ranging from 45 to 180 µg. cm^{-3} (Table1).

Sodium is a constant element of water, but concentrations can be extremely variable. Independently leaching geological formations containing sodium chloride, the salt may be derived from the decomposition of mineral salts such as sodium aluminum silicates, of marine origin benefits, the coming of salt water into aquifers, many industrial uses etc... [28]. According to the results of analyzes, Sodium concentrations were found in between 60 to 575 µg. cm^{-3} (Table 1). 78% of groundwater samples studies were found within the prescribed limit (200 µg. cm^{-3}) and 28% of samples were found to possess high sodium values. To rich waters chlorides are corrosive and laxative [29,30]. The concentration of chlorides in the water also depends on the terrain crossed. Based on the results of the samples, chloride content is the order of 86 µg. cm^{-3} and 870 µg. cm^{-3}. According to WHO and Algerian standards for water potability [23,24], 60% of the groundwater samples from Tindouf are found to possess high chloride values (Table 1).

The potassium content of 85% water samples collected is always less than the Algerian standards (10 µg. cm^{-3}). Where, it varies from 2 to 21 µg. cm^{-3}. While, the Total Alkalinity of groundwater samples do not exceed the permissible limit proposed in the Algerian standards. It varies from 9 to 30°F (Table 1). The water alkalinity is mainly due to the presence of bicarbonates. It is a measure of the water capacity to neutralize acids and it reflects its inherent resistance to changes in pH. The High potassium values may cause nervous and digestive disorder [26].

Sulphate minerals are widely distributed in nature, and the sulphate anion (SO_4^{2-}) is a common constituent of unpolluted water. Sulphates may be leached from most sedimentary rocks, with appreciable contributions from such sulphate deposits as gypsum [26]. Bicarbonate is the most abundant anion and ionic species generally, in stream water, and therefore has a dominating role in electrical conductivity [21]. Bicarbonate and carbonate ions in water can remove toxic metals, such as lead and cadmium, by precipitating the metals out of solution [31,32]. In the present study, sulphate concentration varies between 180 µg. cm^{-3} and 875 µg. cm^{-3} and exceeds the Algerian standards. But the bicarbonate content in the study area varies in the range 107 to 360 µg. cm^{-3} and found within the prescribed limit (Table 1).

Nitrites are also widely present, but at much lower levels than the nitrates. Nitrites derived from an incomplete oxidation of organic matter. Such as nitrates, nitrites are widespread in the environment, each other are found in most food products, in the atmosphere and in much of the water. The high contents correspond to the reduction of nitrate to nitrite by the sulphite-reducing anaerobes. The presence of nitrite in substantial quantity in the water degrades the quality of the water and may affect human health. The nitrite-related toxicity is very significant because of their oxidizing power [20,33]. From these results obtained nitrites varie from 0 to 0.45 µg. cm^{-3}. These values are found within the prescribed limit in the Algerian standards (Table 1).

Constituents	**pH**	**EC ms.cm-³**	**Ca mg.l-¹**	**Mg mg.l-¹**	**Na mg.l-¹**	**K mg.l-¹**	**Cl mg.l-¹**	**SO_4 mg.l-¹**	**NO_3 mg.l-¹**	**HCO_3 mg.l-¹**	**TH (F°)**	**TAC (F°)**	**NO_2 mg.l-¹**	**F mg.l-¹**
Minimum	6.15	1.08	45	45	60	2	86	180	3.2	107	43	09	0	0.16
Maximum	7.77	4.34	202	180	575	21	870	875	120	360	101	30	0.45	3.31
Overage	7.18	2.38	105	121.6	207.37	7.86	315	446	73.37	286.85	74.75	23.62	0.035	2.05
OMS standars	6.5– 9.5	2500	100	50	200	10	250	250	50	/	200 ppm	/	0.2	1.5
ADW standars	6.5- 8.5	2280	75	150	200	10	200	200	50	/	100 ppm	/	0.1	1

Table 1: physicochemical parameters of groundwater simples, OMS and ADW standard.

Ionic balance

The water physicochemical analysis necessarily includes the elements necessary for the establishment of the ionic balance: it then checks that the sum of cations is equal to that of anions, for its major ions: calcium, magnesium, sodium and potassium for cations; chlorides, sulfates, nitrates and bicarbonates for anions. The ionic balance results showed that the simple analysis is between acceptable and good analysis

Correlation matrix in upper Visean, upper Ordovician and Continental Tertiary aquifer

The correlation contribution between the groundwater physico-chemical parameters helps to understand certain phenomena generated by the interaction water-rock. It can give an approach to the common origin of certain parameters. It is assumed that correlation is significant, if the value the correlation coefficient "r" is between 0.5 to 1 (Relationship positive) and -0.5 to -1 (negative relationship). We will start with a multivariate approach with the principal component analysis (PCA). The nature of data has imposed the use of this analysis in order to find the relationships between the different variables, and possibly regroup in the similar variation types. The Correlation analysis was employed to understand the interrelationship between fluoride and other Fourteen (14) physico chemical parameters represented in Table 2, 3, 4 for upper Visean, upper Ordovician and Continental Tertiary aquifer respectively. They are taken into account, for the comparison of water points with nearby chemical characteristics. We can say that there is a good correlation between these variables studied and fluoride. The fluoride concentration in groundwater depends upon the following factors like climate, relief, evaporation, precipitation, geology, and geomorphology of the area. It is generally accepted that groundwater is enriched in F- due to prolonged water–rock interactions [34,35]. It is observed that the ratio of Na+/Ca+, Na+/Cl- and NO_3- are increased with reference to the increase in fluoride concentration (Figure 5a, 5d, 5e) in all Tindouf aquifer. The present study area represents very high fluoride content with a maximum of 3.31 mg/L in Tindouf groundwaters which are source of drinking water. Thus, it conclude that geological location is one of the most important factors affecting groundwater quality.

Variable	pH	EC	Ca	Mg	Na	K	Cl	SO_4	NO_3	HCO_3	TH	NO_2	F
pH	1												
EC	-0,422	1											
Ca	0,720	-0,329	1										
Mg	-0,746	0,752	-0,835	1									
Na	-0,337	0,979	-0,295	0,706	1								
K	-0,641	0,573	-0,805	0,783	0,477	1							
Cl	-0,279	0,966	-0,281	0,664	0,992	0,503	1						
SO4	-0,561	0,892	-0,336	0,774	0,797	0,569	0,746	1					
NO_3	-0,152	0,081	-0,362	0,448	-0,004	0,185	-0,077	0,382	1				
HCO_3	0,631	0,376	0,357	-0,079	0,393	0,005	0,450	0,224	0,067	1			
TH	-0,348	0,907	-0,144	0,665	0,872	0,312	0,816	0,932	0,323	0,359	1		
NO_2	-0,096	0,501	0,148	0,054	0,597	0,026	0,633	0,160	-0,785	0,106	0,292	1	
F	-0,922	0,266	-0,881	0,777	0,171	0,722	0,121	0,445	0,395	-0,603	0,191	-0,222	1

Table 2: Correlation matrix of the upper Visean aquifer waters.

Variable	pH	EC	Ca	Mg	Na	K	Cl	SO_4	NO_3	HCO_3	TH	TAC	NO_2	F
pH	1													
EC	0,975	1												
Ca	0,997	0,955	1											
Mg	-0,940	-0,992	-0,912	1										
Na	0,970	1,000	0,950	-0,995	1									
K	0,996	0,991	0,987	-0,967	0,988	1								
Cl	0,988	0,998	0,974	-0,981	0,996	0,998	1							
SO_4	1,000	0,970	0,998	-0,933	0,966	0,994	0,985	1						
NO3	-0,879	-0,751	-0,912	0,663	-0,738	-0,833	-0,795	-0,888	1					
HCO_3	-0,946	-0,850	-0,968	0,779	-0,840	-0,914	-0,885	-0,952	0,986	1				
TH	0,984	0,919	0,995	-0,864	0,912	0,964	0,945	0,987	-0,950	-0,989	1			
TAC	-0,942	-0,843	-0,964	0,771	-0,833	-0,908	-0,879	-0,948	0,988	1,000	-0,987	1		
NO_2	0,895	0,972	0,860	-0,994	0,976	0,932	0,953	0,887	-0,575	-0,703	0,802	-0,694	1	
F	-0,919	-0,808	-0,946	0,729	-0,796	-0,880	-0,847	-0,926	0,996	0,997	-0,975	0,998	-0,647	1

Table 3: Correlation matrix of the of upper Ordovician aquifer waters.

Variable	pH	EC	Ca	Mg	Na	K	Cl	SO_4	NO_3	HCO_3	TH	TAC	NO_2	F
pH	1													
EC	0,090	1												
Ca	-0,039	0,469	1											
Mg	-0,154	0,411	-0,389	1										
Na	0,265	0,850	0,302	0,151	1									
K	0,472	-0,039	0,112	-0,439	0,146	1								
Cl	0,069	0,908	0,525	0,354	0,745	-0,122	1							
SO_4	0,144	0,839	0,462	0,258	0,736	0,103	0,637	1						
NO_3	0,276	0,498	0,251	0,235	0,417	-0,245	0,650	0,232	1					
HCO_3	-0,199	0,073	-0,460	0,444	0,086	-0,147	-0,144	-0,046	-0,326	1				
TH	-0,168	0,806	0,456	0,640	0,423	-0,315	0,788	0,657	0,442	0,044	1			
TAC	-0,195	0,164	-0,392	0,454	0,164	-0,145	-0,071	0,051	-0,283	0,986	0,116	1		
NO_2	0,041	-0,021	0,064	-0,105	0,047	-0,080	-0,022	0,006	-0,106	0,048	-0,056	0,022	1	
F	-0,045	0,186	0,089	0,078	0,129	-0,039	0,099	0,185	-0,002	0,248	0,143	0,258	-0,057	1

Table 4: Correlation matrix of the Continental Tertiary aquifer waters.

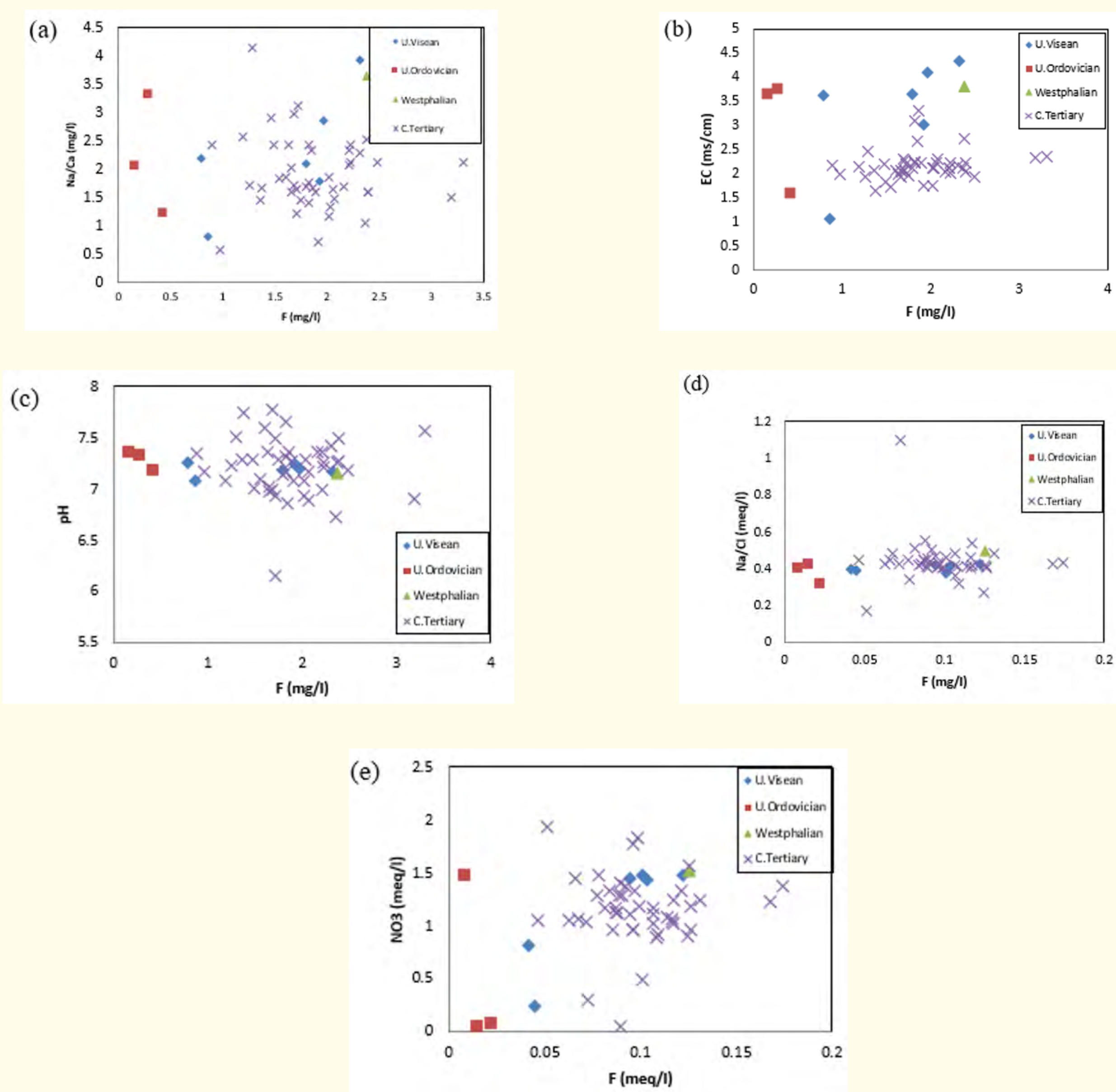

Figure 5: Relationship among fluoride and other elements in the groundwater of Tindouf aquifer.

Experimental

The Principal Components Analysis (PCA)

The aquifer analysis is performed a centered reduced PCA. According to the Kaiser criterion, only two factors were selected (F1 and F2) which represent 78%, 100% and 54% of the total variance in upper visean, ordovician and continental tertiary aquifer. Where, F1 represent 51%, 92%, 35% and F2 represent 26%, 8%, 18% respectively. It is interesting to identify the main variations in water chemistry. F1 is positively determined by (EC, NO_3, Cl, Ca, Mg, Na, HCO_3 and F). This is the contamination factor highlighting a mineralization of water by the dissolution phenomenon of the rocks. So, F1 factor defines a general mineralization axis of water. However, this axis combinations show that these elements are produced by two different solution mechanisms. Ca^2+, Mg^2+ and TH are derived from the rocks weathering following a long contact time water-rock and acid hydrolysis of silicate minerals, while sandstones, limestone, dolomite and clay aquifer formations contain significant fluoride concentrations. These formations are the main lithological components of the aquifers in the Tindouf region.

Hydrochemical facies

Piper trilinear plot was used to help in the classification of the waters of Tindouf groundwater. The water of Continental Tertiary aquifers were relatively dominated by alkaline earth (Ca + Mg), with a tendency of $S0_4$ and Cl. But the waters of upper Ordovician and Upper Visean aquifers were strongly dominated by alkaline earth (Ca + Mg), with a tendency of (Na + Cl) and K or (Na + SO_4) (see Figure 6). Local geological conditions due to the enrichment and depletion of ions resulting from dissolution of mineral contents of the aquifer sediments associated with the recharge and discharge processes [36].

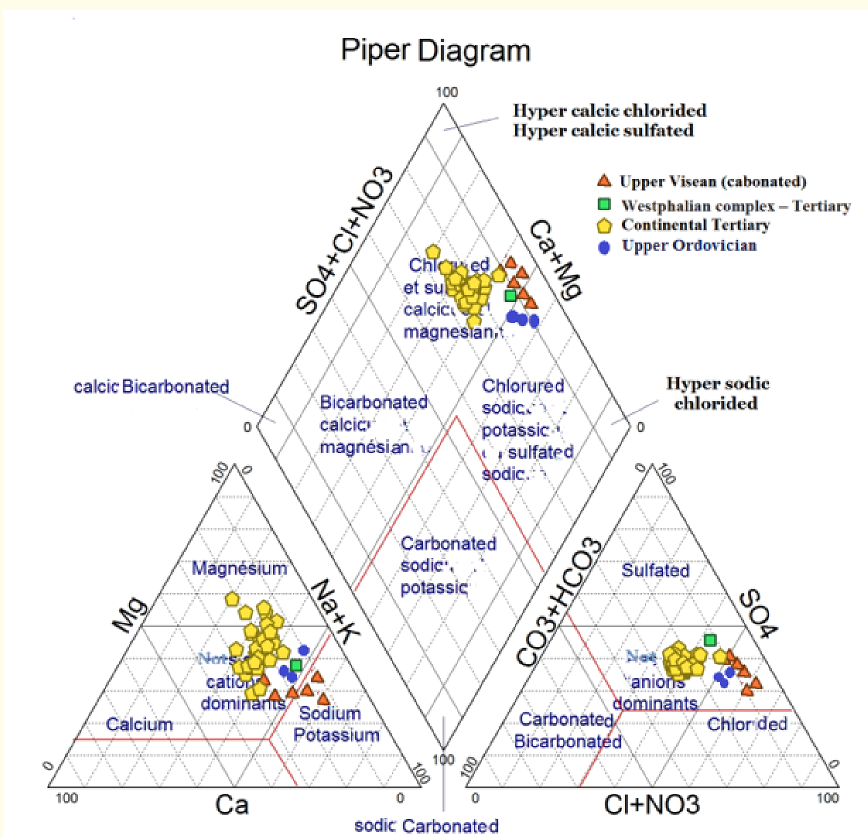

Figure 6: Triangular diagram Piper companion of Continental Tertiary, Westphalian – Tertiary, upper Ordovician and upper Visean aquifer.

Conclusions

The current study based on the quality of Groundwater exploited in Tindouf syncline, which are influenced by aquifer formation minerals. Indeed, 74% borehole waters exceed the permissible limit of fluoride concentration, cited in Algerian standards and WHO standards. The fluoride concentration varied from 0.16 to 3.31 $\mu g.\ cm^{-3}$ in upper Ordovician, Westphalian complex – Tertiary, upper Visean and Continental Tertiary aquifer. The geochemical trend of groundwater in the study area demonstrates that sodium is the dominant cation (Na+ > Ca^{+2} > Mg^{+2} > K+) and sulphate is the dominant anion (SO_4^{-2} > Cl- > HCO_3- > NO_3- > F-).

Physicochemical parameters analysis was showed that the most physicochemical parameters exceed the permissible limit cited in Algerian standards and WHO standards. There is a considerable increase in chloride, sodium total hardness, fluoride, nitrate and sulfate. It shows that there is possible contamination of groundwater of Tindouf region.

The analysis reveals that the groundwater of the area needs certain degree of treatment before, and it also needs to be protected from the perils of contamination. More in addition, Face to the rarefaction of the resources in alimentary waters of good quality in South of Algeria (Sahara), the treatment of the waters with a great content of fluoride will become a necessity to protect the health of habitation. This detailed study of water quality in this region is necessary to recommend the most appropriate treatment technology.

Bibliography

1. Pandey SK and S Tiwari. "Physico- chemical analysis of groundwater of selected area of Ghazipur city-A case study". *Nature Science* 7.1 (2009): 17-20.
2. Buridi KR and RK Gedala. "Study on Determination of Physicochemical Parameters of Ground Water in Industrial Area of Pydibheemavaram, Vizianagaram District, Andhra Pradesh, India". *Austin Journal of Public Health and Epidemiology* 1.2 (2014): 02-03.
3. Benrabah S., *et al*. "Characterization of groundwater quality destined for drinking water supply of Khenchela City (eastern Algeria)". *Journal of Water and Land Development* 30 (2016): 13-20.
4. Patil PN., *et al*. "Physico-chemical parameters for testing of water-A review". *International Journal of Environmental Sciences* 3.3 (2012): 1192-1207.
5. Ouyang Y., *et al*. "Characterisation of shallow groundwater quality in the Lower St. Johns River Basin: a case study". *Environmental Science and Pollution Research* 20 (2013): 8860-8870.
6. Brindha K., *et al*. "Fluoride in weathered rock aquifers of southern India: Managed Aquifer Recharge for mitigation". *Environmental Science and Pollution Research* 23 (2016): 8302-8316.
7. Shirazi SM., *et al*. "Groundwater quality and hydrogeological characteristics of Malacca state in Malaysia". *Journal of Water and Land Development* 24 (2015): 11-19.
8. Rizwan U., *et al*. "Assessment of groundwater contamination in an industrial city, Sialkot, Pakistan". *African Journal of Environmental Science and Technology* 3.12 (2009) : 429-446.
9. Karunanidhi G., *et al*. "Evaluation of the groundwater quality feasibility zones for irrigational purposes through GIS in Omalur Taluk, Salem District, South India". *Environmental Science and Pollution Research* 20 (2013): 7320-7333.
10. Gupta D P., *et al*. "Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India". *Researcher* 1.2 (2009): 1-5.
11. Laouni S E., *et al*. "Physico-chemical caracteristics and quatily of feed waters of the El-Oued city study of case (Fluorine and Arzenic)". *International Journal of Fundamental and Applied Sciences* 1.2 (2009) : 13-22.
12. Othman C O., *et al*. "Use of Activated Red Clay Soil from Kiteto District, Tanzania, as a Remedial Method for High Fluoride Levels in Drinking Water". *International Journal of Science, Technology and Society* 2.5 (2014): 115-120.
13. Miller-Ihli NJ., *et al*. "Fluoride content of municipal water in the United States: What percentage is fluoridated?". *Journal of Food Composition and Analysis* 16 (2003): 621-628.
14. Youcef L., *et al*. "Defluoridation groundwater southern Algerian For lime and aluminum sulphate". Mail Know. 1 (2001): 65-71.
15. Kebir L. Prospecting hydrogeological in the Tindouf basin using data Optical and Radar (cas basin Watershed Oued El Ma). Proceedings of the scientific and technical workshop on "Space Tool for Development". Palace of Culture Moufdi Zakaria Algiers. Algeria. (2009).
16. Hani AI. "Dentification des axes d'écoulement souterrains dans les systèmes aquifères du bassin de Tindouf et des plaines de Annaba-Bouteldja". Hydrology of lite Mediterranean and Semiarid Regions (Proceedings of an international symposium held at Montpellier. April 2003). (2003).
17. Belkhodja M and Benseradj. Development of geological knowledge and oil problems. Tindouf Basin. internal report SH/Exploitation/ District-7.
18. Idrotecnica hydrogeological study of the Tindouf region. Final Report DROGE / AO-623. (1979).
19. Rodier J. Analysis of waters. 9th edition. Dunod, Paris. (2009).
20. Rajendran R., *et al*. "Assessment of physico- chemical parameters of river cauvery in and around Nerur". *Journal of Environmental Science and Pollution Research* 1 (2015): 17-19.

21. Kura N U., *et al*. "An overview of groundwater chemistry studies in Malaysia". *Environmental Science and Pollution Research* (2015): 1-19.

22. Ambrina S K and Prateek S. "Physico-chemical characteristics of Ground water in and around Allahabad City: A Statistical Approach". *Bulletin of Environmental and Scientific Research* 1.2 (2012): 28-32.

23. ADW. Algerian drinking water standards. Norm. Al. 6360, Ed. Ianor. (1992).

24. WHO. Guidelines for drinking-water quality, 4th edition, recommendations. World Health Organization, Geneva. 1 (2011).

25. Laluraj CM and Gopinath G. "Assessment on seasonal variation of groundwater quality of phreatic aquifers-a river basin system". *Environmental Monitoring and Assessment* 117 (2006): 45-57.

26. Kalyana R B and Rupa K G. "Study on Determination of Physicochemical Parameters of Ground Water in Industrial Area of Pydibheemavaram, Vizianagaram District, Andhrapradesh, India". *Austin Journal of Public Health and Epidemiology* 1 (2014): 1-2

27. Evens E., *et al*. "Characterization of hardness in the groundwater of port-au-prince. An overview on the health significance of magnesium in the drinking water". *Aqua-LAC* 5.2 (2013): 35-43.

28. Wojciech O and Krzysztof P. "Magnesium, calcium, potassiumAnd sodium content In groundwater and surface Water in arable lands In the commune (gmina) of kyty". *Journal of Elementology* 13.4 (2008): 605-614.

29. Panno S V., *et al*. "Characterization and Identification of Na-Cl Sources In Ground Water". *Ground Water* 44 (2006): 176-187.

30. Ahmed Sabo., *et al*. "Physicochemical and bacteriological quality of ground water at abubakar tatari ali polytechnic bauchi, Nigeria". *European Scientific Journal* 10.18 (2014): 466-478.

31. Davis S N., *et al*. "Uses of chloride/bromide ratios in studies of potable water". *Ground Water* 36 (1998): 338-350.

32. Brian GK., *et al*. "Using Cl/Br ratios and other indicators to assess potential impacts on groundwater quality from septic systems: A review and examples from principal aquifers in the United States". *Journal of Hydrology* 397 (2011): 151-166.

33. Hossain M A., *et al*. "Mobilization of arsenic from subsurface sediments by effect of bicarbonate ions in groundwater". *Chemosphere* 54 (2004): 753-762.

34. Narsimha A., *et al*. "Contamination of fluoride in groundwater and its effect on humanhealth: a case study in hard rock aquifers of Siddipet, Telangana State, India". *Applied Water Science* (2016): 1-12.

35. Saxena VK and Ahmed S. "Dissolution of fluoride in groundwater: a water-rock interaction study". *Environment Geology* 40 (2001): 1084-1087.

36. Venkatramanan S., *et al*. "Comprehensive studies of hydrogeochemical processesand quality status of groundwater with tools of cluster, groupinganalysis, and fuzzy set method using GIS platform: a case study of Dalcheon in Ulsan City, Korea". *Environmental Science and Pollution Research* 22.15 (2015): 11209-11223.

Volume 3 Issue 6 June 2019