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Fluoride ion contamination of groundwater in Guidan Roumji Department, Niger

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Abstract
The objective of this study is to identify natural sources of fluoride ion contamination in groundwater in Guidan Roumji Department, Niger. Samples of drilling water trapping said sheet were taken and certain physicochemical parameters determined. The fluoride ion content of the water sampled varies from 0.49 to 2.17 mg / L and indicates that some of the borehole water in Guidan Roumji Department is unfit for consumption. The results of the correlations between fluoride ions and other ions show that the dissolution of hornblende is the main source of contamination by fluoride ions in groundwater, in the Department of Guidan Roumji in Niger.

Keywords: Groundwater, contamination, fluorides, Guidan Roumji, Niger

Introduction
In arid zones, the scarcity of surface water makes groundwater often the only source of drinking water [1]. Some groundwater contains fluoride ions at a concentration that exceeds the standards for human consumption [2]. Work done around the world has shown that populations in some 20 countries are affected by fluorosis [3]. Five thousand children in Tibiri commune in Niger have dental and / or skeletal fluorosis due to the consumption of drilling water containing fluoride ions [4]. To our knowledge, no previous study has indicated the natural sources of fluoride ion contamination of these groundwater in the study area. According to some authors, the presence of fluoride ions in groundwater may have several reasons, including: the nature of aquifer rocks [5], the contact time between water and rocks [2] and control chemical [6]. Natural contaminations are mostly geological [7, 8]. The objective of this study is to identify natural sources of fluoride ion contamination in groundwater in Guidan Roumji Department, Niger.

Materials and methods
In 2017 borehole water samples were collected from the Guidan Ruimji Department in Niger. The map below shows the Guidan Rumji Department in Niger.

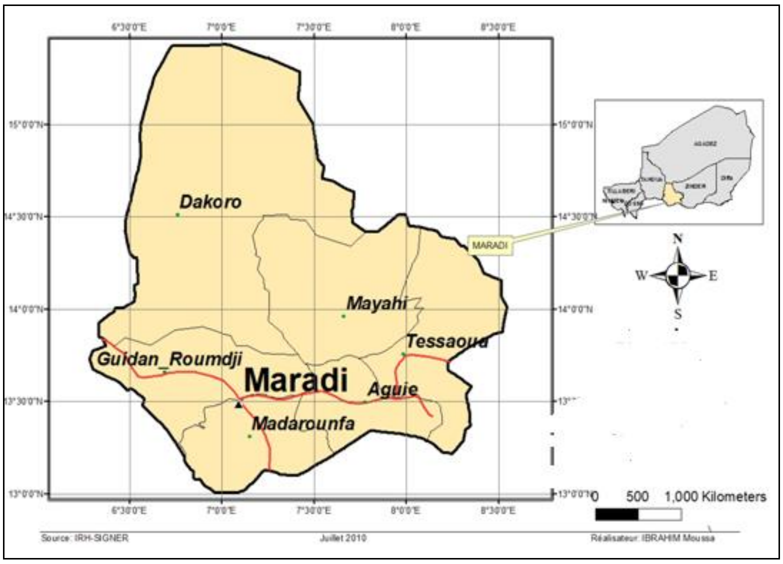

Fig 1: Location of the study area in Niger [9]

Water samples were collected in polyethylene bottles. The flasks were pre-soaked in dilute HCl solution 1: 1 for 24 h and then washed with distilled water. Before any sampling, the drilling water is pumped for about 10 minutes. The bottle is first rinsed with water sampled and then completely filled to prevent air bubbles. The samples taken were transported to the laboratory in coolers and then filtered with Millipore 0.45 µm filter paper. In the laboratory, the samples were stored at a temperature of 4 ° C. The pH was measured in situ using a HI 991001 pH meter. Electrical conductivity and temperature were measured in situ using a RS232 type conductivity meter. The calcium and magnesium contents were determined by complexometry with EDTA. The content of fluoride ions was determined by spectrometry using a spectrophotometer of DR3900 type at the wavelength of 580 nm. Phosphorus was assayed by molecular absorption spectrometry with a 6715 UV spectrophotometer. The sodium ion content was determined by flame spectrometry using a PFP7 flame photometer.

Results and discussion

Table 1: The table below gives the locations where the samples were taken and the values of the physicochemical parameters.

villages	T°C	pH	Conductivité (µS/cm)	F^- (mg/L)	Na^+ (mg/L)	Ca^{2+} (mg/L)	PO_4^{3-} (mg/L)	Mg^{2+} (mg/L)
Fissataou	29.6	7.41	900	1.98	6	4	0.12	17.28
Guidan Roumji	33.9	9.04	1521	1.19	14	6.4	0.1	3.36
Hannou Gazané	30.6	7.21	258	0.49	5	7.2	0.2	34.08
Karazomé	31.9	7.60	285	2.17	18	24	0.3	67.2
Sawa Samia	30.7	7.80	689	1.35	6	2.4	0.2	6.72
Zabouré	31.3	7.24	221	1.79	12	12	0.04	62.4

The data in the table above shows that the temperature of the collected water varies between 29.6 and 33.9 ° C. According to MAKHOUKH *et al* 2011, This higher or lower water temperature promotes the precipitation of carbonates (calcite) and evaporites (gypsum) that it contains [10]. It also acts on the density of water, its viscosity, its solubility of gases, its dissociation of dissolved salts, as well as on chemical reactions. The pH of the sampled waters varies between 7.21 and 9.04. These pH values indicate that the waters analyzed have an alkaline character. According to MAKHOUKH *et al* 2011, This alkaline medium promotes the release of fluoride ions [10]. The results of the table also show that apart from the sample taken in the locality of Guidan Roumji (conductivity equal to 1521µs / cm), all the other samples have an acceptable mineralization for the consumption with a conductivity lower than the norm (WHO) (1250 µs / cm). These conductivity values indicate a weak water-rock interaction in the aquifers of the study area. The calcium concentration of the water varies between 2.4 and 4 mg / L and the magnesium concentration varies between 3.36 and 67.2 mg / L. These values indicate that the waters sampled are freshwater.

Correlation study

According to Mignon, the basement of the study area consists of a crystallophyllian sequence, mainly composed of schists, quartzoschists, gneiss, and biotite porphyry granite. Selon lui toujours, ces roches sont métamorphisées dans les faciès schistes verts ou amphibolite [11]**.** According to Saxena, and Ahmed, sandstones contain up to 180 ppm fluoride, limestone 220 ppm fluoride, clays 800 ppm fluoride [12]. According to Srikanth [13] *et al*, 2002, one of the geological phenomena responsible for the contamination of groundwater by fluoride ions is the dissolution of certain rocks: fluorite, biotite, cryolite, fluoroapatite and / or hornblende [13]. The following figures give the correlations: (Na^+, F^-), (F-, PO_4^-), (F^-, Ca^{2+}), (F^-, Mg^{2+}), (F^-, pH), (Na^+, Mg^{2+})(Ca^{2+}, Mg^{2+}) their coefficients.

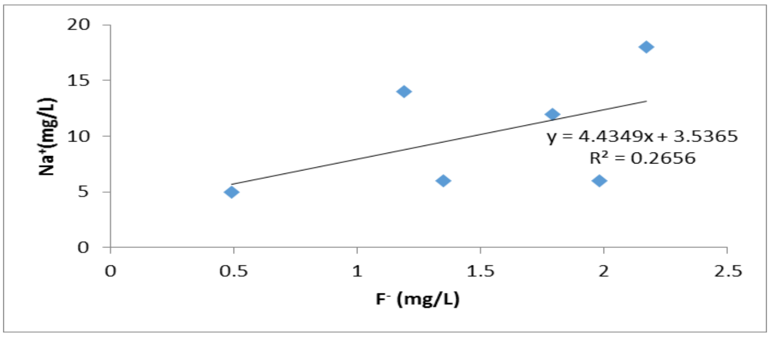

Fig 2: Correlation curve between fluorine and sodium

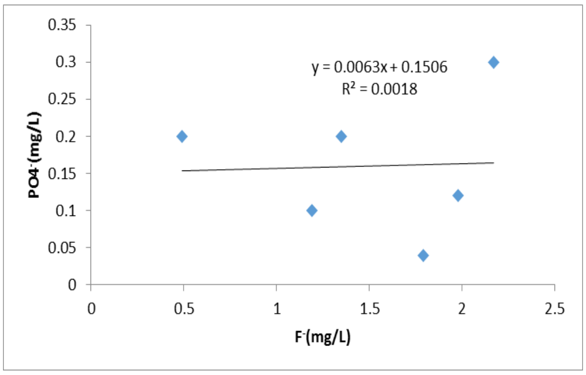

Fig 3: correlation curve between fluorine and phosphorus

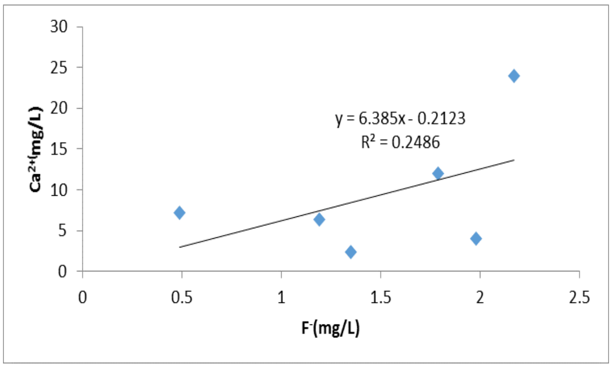

Fig 4: Correlation curve between fluorine and calcium

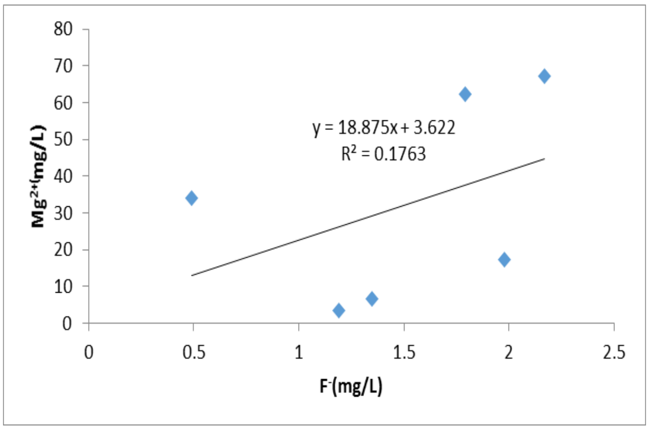

Fig 5: Correlation curve between fluoride and magnesium

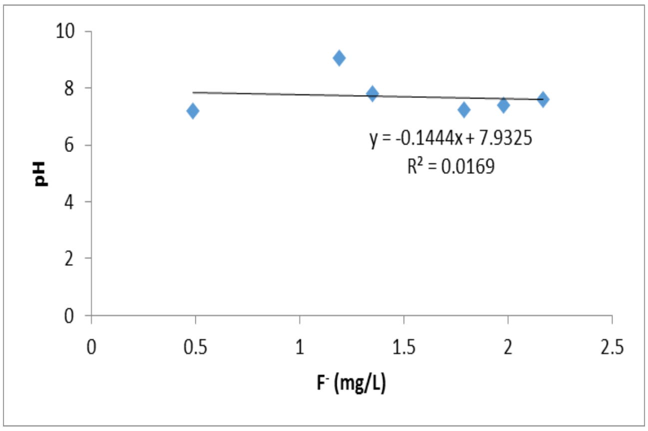

Fig 6: Correlation curve between fluoride and water pH

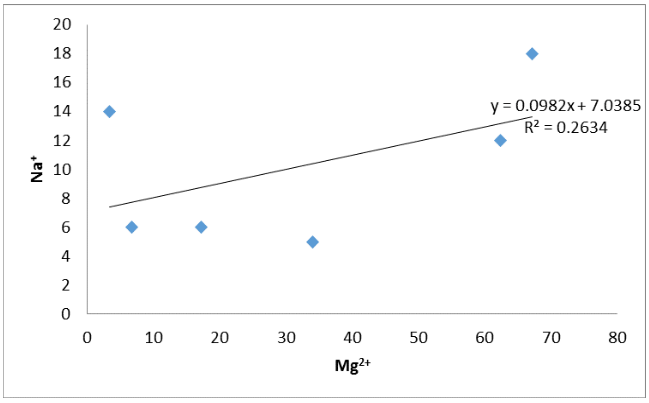

Fig 7: Correlation curve between sodium and magnesium

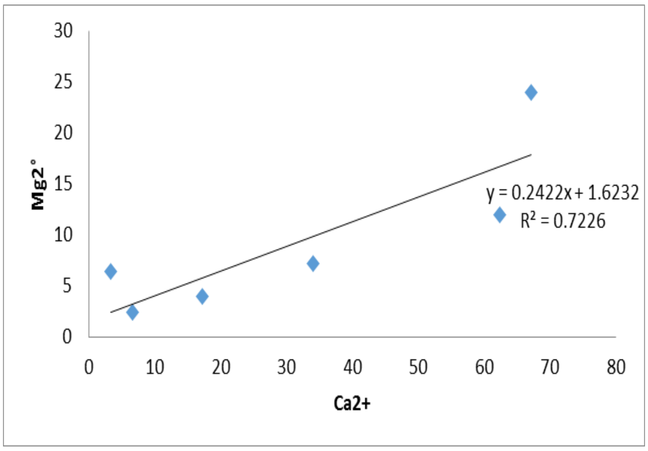

Fig 8: correlation curve between calcium ions and magnesium ions

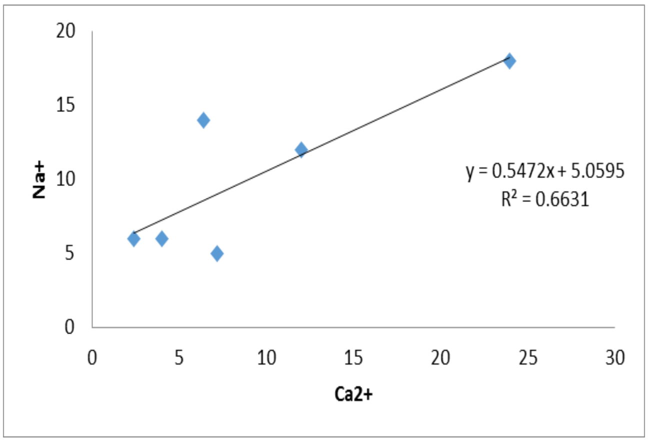

Fig 9: correlation curve between sodium ions and calcium ions

The correlation coefficient between the fluoride ions and the sodium ions (FIG. 2) is r = 0.51. This correlation coefficient indicates that the dissolution of the compound containing both sodium and fluorine will contribute to the fluoridation of groundwater in Guidan Roumji Department. Similarly, the correlation coefficient between the fluoride ions and the magnesium ions (FIG. 5) with r = 0.42 indicates that the dissolution of the compound containing both magnesium and fluorine will contribute to the fluoridation of the groundwater of the zone study. Also, the coefficient of correlation between sodium ions and magnesium ions (Figure 7) with r = 0.46 indicates that some sources of sodium ions encountered in the groundwater of the study area are also sources of magnesium ions. The coefficient of the correlation between the fluoride ions and the phosphate ions (FIG. 3) with r = 0.03 indicates that the contribution of the phosphate compounds (fluoroapatite) to the fluoridation of these groundwater is too low. According to SAIDOU Nourou Diop [8], 2010 and ANIS Ben Nasr, 2014 [7], the dissolution of fluoroapatite (Ca10 (PO4) 2F2) in aquifers is more favorable at a temperature above 35 ° C. However, the temperatures of the samples taken are all less than 35 ° C. Therefore, they are not favorable to the dissolution of fluoroapatite. The foregoing may explain the weak correlation between fluoride ions and phosphate ions, indicating the very low participation of fluoroapatite dissolution in the fluoridation of groundwater in the study area. The coefficient of the correlation between the fluoride ions and the calcium ions (FIG. 4), (r = 0.49) indicates a no less important contribution of the dissolution of compounds containing both calcium and fluorine to the fluoridation of the waters. Underground in the study area. The correlation coefficient between fluoride ions and water pH (Figure 6), (r = 0.12) indicates a very weak influence of pH on the transfer of fluoride ions in the groundwater of the study area. The coefficients of the correlations: (calcium-magnesium, r = 0.85), (sodium-calcium, r = 0.81) indicate a very strong relationship between calcium and magnesium on the one hand and then between sodium and magnesium on the other hand. The dissolution of hornblende according to the equation:

$CaNa(Mg,Fe,Al)(Si_7Al)O_{22}(OH,F)_2 + H_2O + CO_2\ Ca + Mg + Na + Fe(OH)_3 + HCO_3 + 2F + Al_2Si_2O_5(OH)_4 + SiO_2$

Indeed, according to Kim and Jeong, 2005, when hornblende minerals interact with groundwater and carbon dioxide, ions such as calcium, magnesium, sodium and fluoride escape from the aquifer matrix to groundwater [15].

Thus, considering the coefficients of the correlations: (fluorides - sodium, r = 0.51); (fluorides - calcium, r = 0.49) and (fluorides - magnesium, r = 0.42), (sodium-magnesium, r = 051), (calcium-magnesium, r = 0.85), (sodium-calcium, r = 0.81) we can say that the dissolution of hornblende is a major natural source of groundwater fluoridation in the Guidan Roumji Department of Niger.

Conclusion

The objective of this study is to identify the natural sources of contamination by fluoride ions from groundwater in the Guidan Roumji Department of Niger. This study shows that: some populations in Guidan Roumji Department who consume some drilling water are at risk of dental and / or skeletal fluorosis; the dissolution of hornblende is a major natural source of groundwater fluoride contamination in the Guidan Roumji Department of Niger; there is a need for the establishment of a defluoridation device for the drilling water that some populations consume in the Department of Guidan Rumji.

Acknowledgments

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