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Impact of the depth of groundwater in the Continental Intercalaire and/or Hamadien aquifers on the variation in fluoride ion content (Maradi Region, central Niger)

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Abstract:
The purpose of this study is to study the impact of the depth of groundwater aquifers in the Maradi region on variations in fluoride ion content. To achieve this objective, the analysis of fluoride ion concentrations in well and borehole water samples was carried out. The depths of the wells and boreholes as well as the piezometric levels of these works have been determined. The lithological logs of some boreholes have been drawn. The results obtained show that the contents of fluoride ions in borehole waters are higher than those obtained in well waters. Also, these results also show that these levels in groundwater in the study area increase with depth.

Key words: *Groundwater, Maradi Region, fluoride ion, aquifer*

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I. Introduction

Renewable fresh water is an essential resource for life [1]. Naturally filtered by the soil, groundwater is most often of good quality [2, 3, 4]. The chemical composition of water from the natural environment is very variable. It depends on the geological nature of the soil from which it comes and also on the reactive substances that it could have encountered during the flow [5]. Groundwater quality can be altered [6, 7, 8, 9, 10]. The climatic changes observed in recent years, characterized by the increase in average temperature and the scarcity of rainfall, have resulted in the deterioration of the quality and availability of water [11]. Such is the case with the presence of fluoride salt in groundwater, which is an undesirable substance, even toxic at very high levels ($[F^-] > 1.5$ mg/L, [12]. Fluoride is known to contaminate groundwater supplies worldwide [13]. In Niger, studies have shown that the waters of the locality of Tibiri in the Maradi region have abnormal levels of fluoride ions [14, 15]. It is therefore imperative to monitor the variations in the fluoride ion content in drinking water in the Maradi region. According to [16, 17], the release of fluoride ions into groundwater generally depends on the mineralogical composition of the rocks. According to [18], the fluoride ion content increases with depth. The objective of this study is to study the impact of the depth of groundwater in the Continental Intercalaire and/or Hamadien aquifers on the variation in fluoride ion content (Maradi region, central Niger).

II. Material And Methods

The map below gives the representation of the Maradi I Niger.

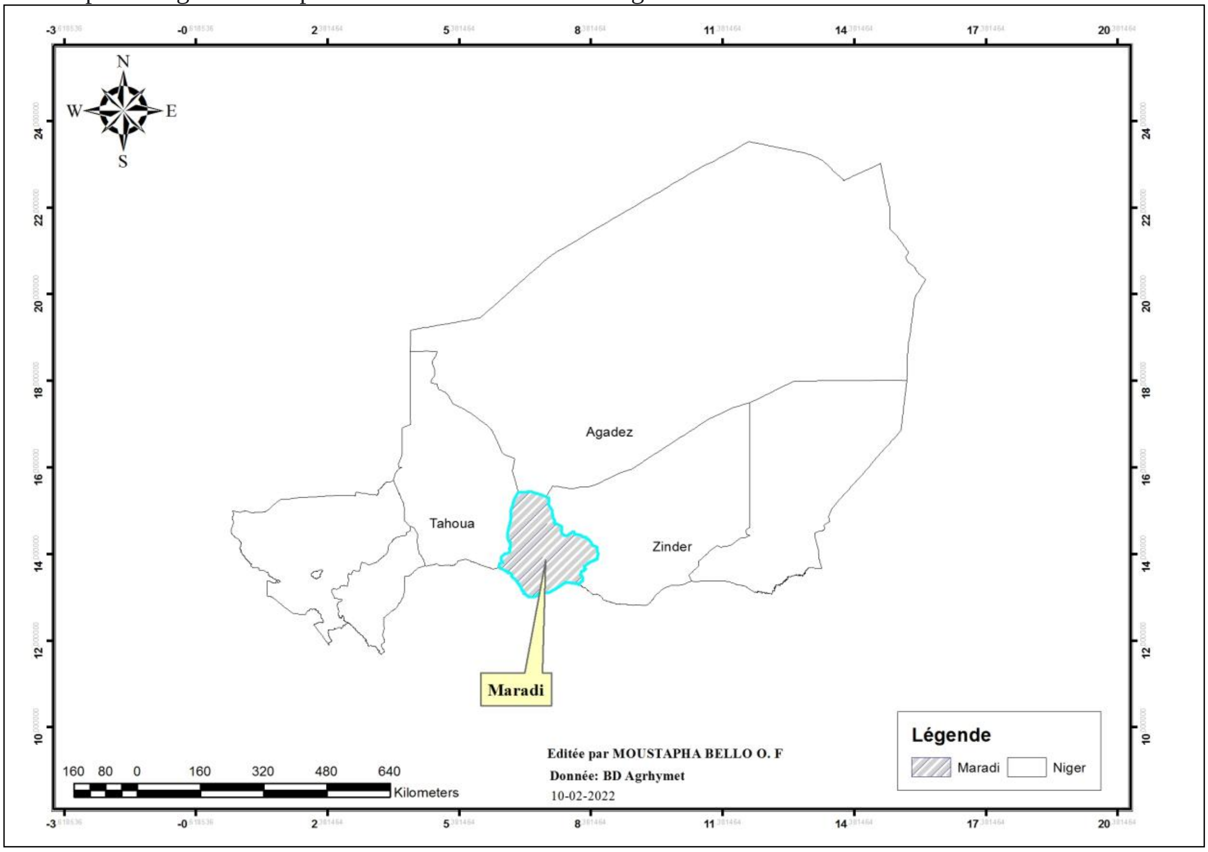

Figure 1: Geographical position of the study area in Niger

During this study, data was first collected on the depths of wells and boreholes at the level of the Regional Direction of Hydraulics of Maradi [14]. The works selected mainly concern wells and boreholes with the highest fluoride ion contents. Thus, in November 2020, water samples were taken from the structures in study area (figure 2).

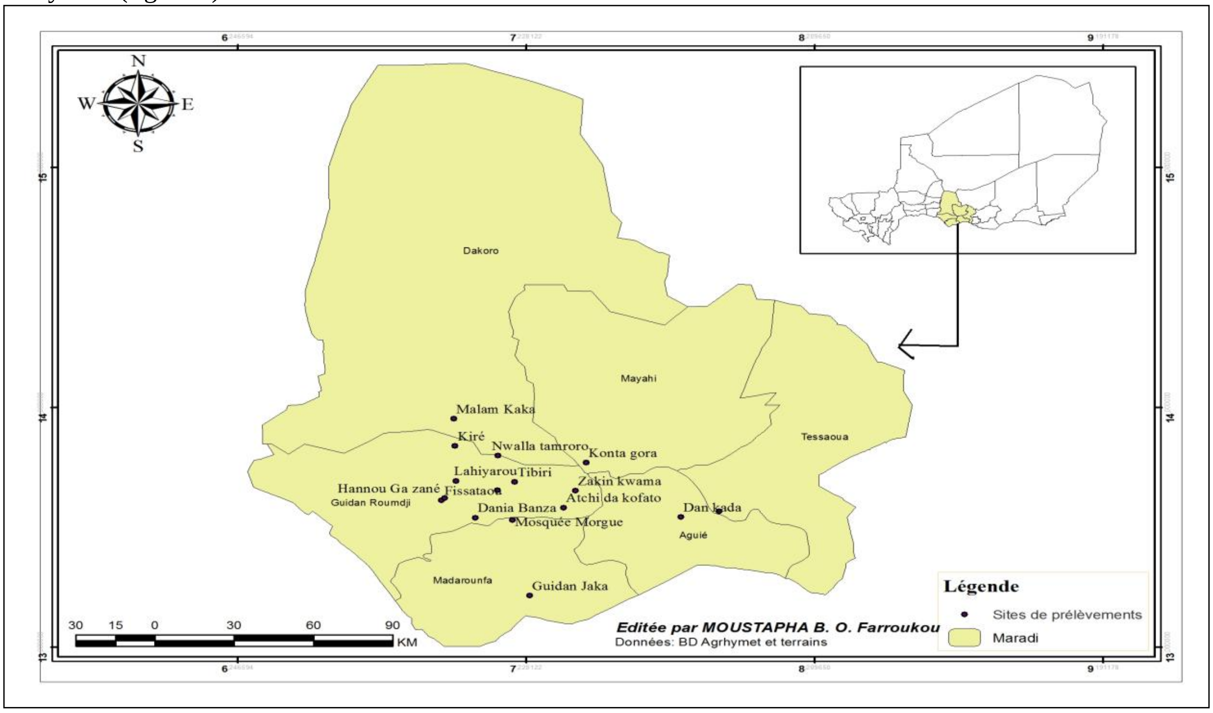

Figure 2: Location of sampling sites

The water samples were taken in polyethylene bottles. The bottles were first washed and then rinsed with distilled water. They were first rinsed with water to be sampled before any sampling. The samples thus taken were transported to the laboratory in appropriate thermoses. The fluoride ion content was determined by spectrophotometry using a DR3900 type spectrophotometer (wavelength = 580 nm).

III. Result

2.1. Fluoride ion content of wells and boreholes

Figure 3 shows the variation in fluoride ion content in well water as a function of depth. Figure 4 shows that of borehole water as a function of depth.

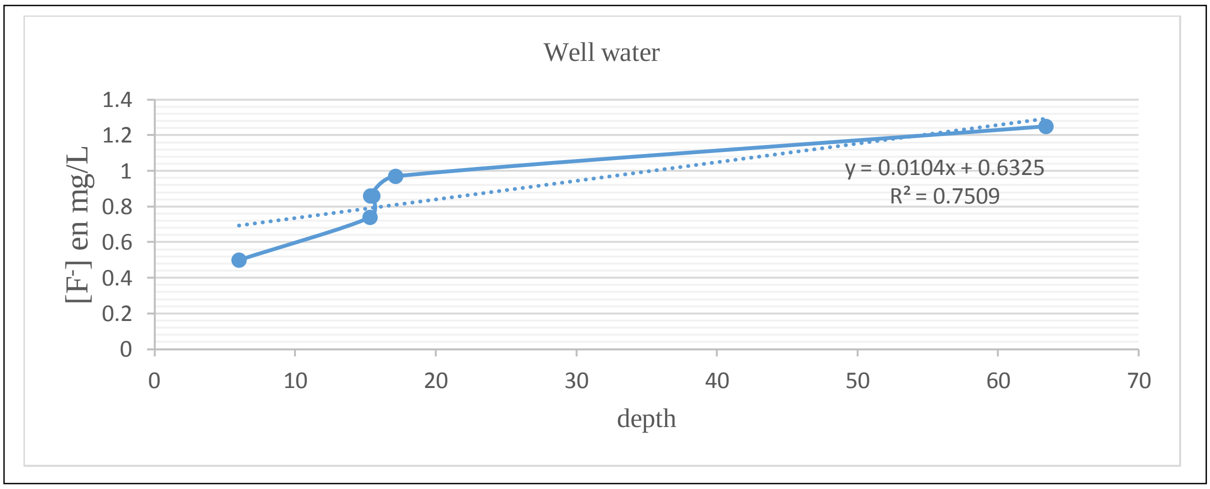

Figure 3: Variation in fluoride ion content as a function of depth (well water)

Figure 4 shows that the fluoride ion contents in the well waters of the Maradi region increase with depth.

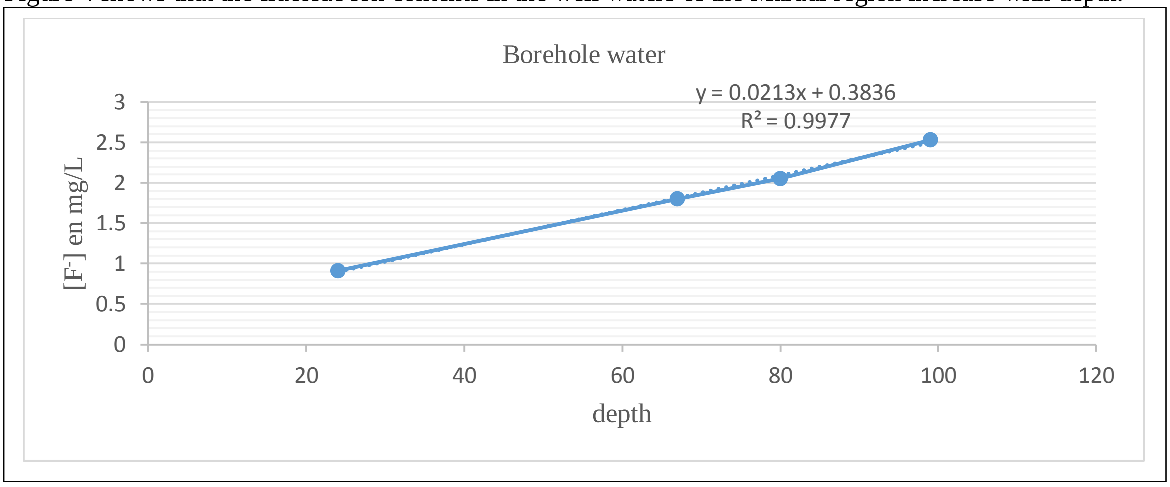

Figure 4: variation in fluoride ion content as a function of depth (borehole water)

Figure 4 shows that the fluoride ion content in the borehole waters of the study area increases with depth. This figure also shows that the fluoride ion contents in all the boreholes exceed the values of the fluoride ion contents obtained in the wells.

2.2. Geological nature and lithological logs of the study area

Figure 5 corresponds to the lithologic section of a borehole (F1) in the study area, the fluoride ion content of which was 6.9 mg/L with a flow rate of 33 m3/h. Figure 6 is that of another borehole (F2) close to the first. The fluoride ion content of the water from this borehole is 0.15 mg/L. These figures show that the soil formations at roof level consist of a sequence of fine sands, fine gravels and fine clay sandstones to a depth of about 75 M. And beyond this depth, clay-type minerals constitute the most abundant fractions of the soil I the study area.

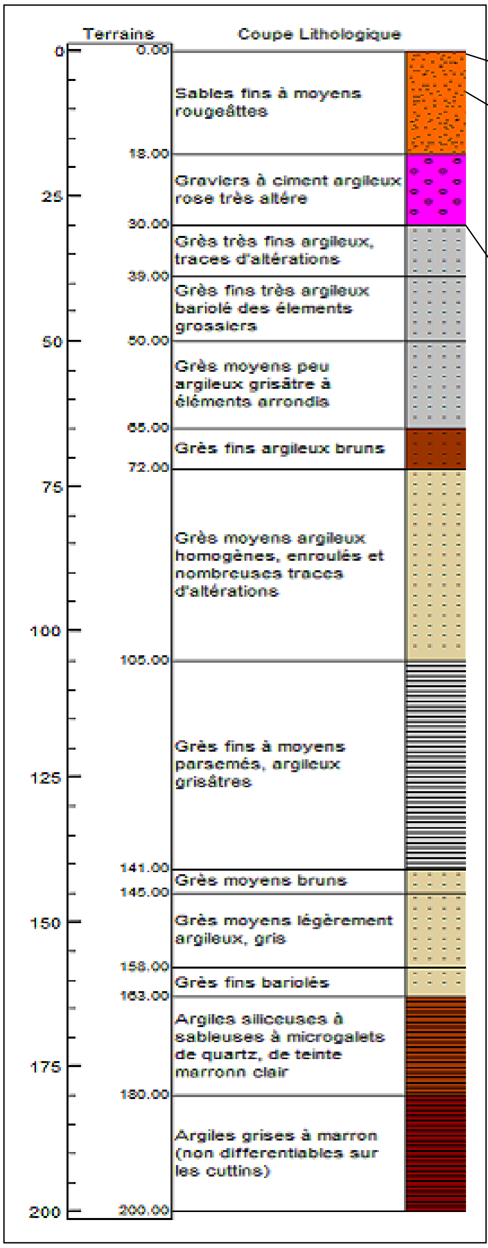

Figure 5: log-lithology of the 1st borehole (F_1)

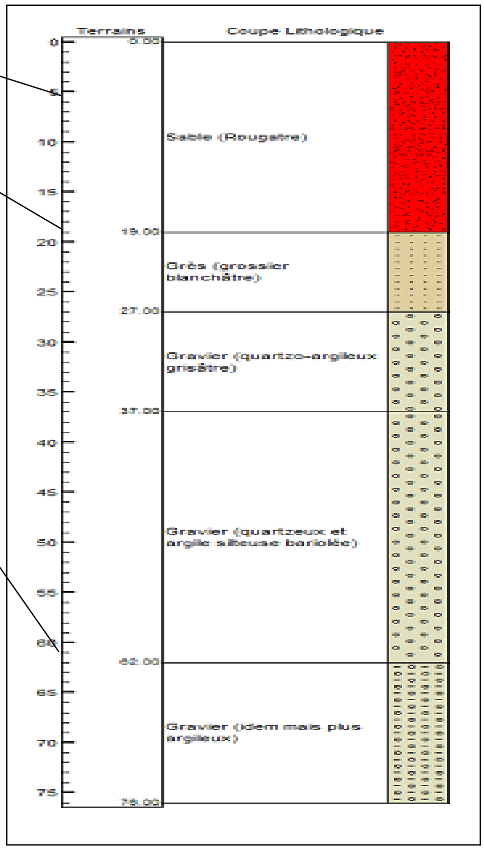

Figure 6: log-lithology of the 2nd borehole (F_2)

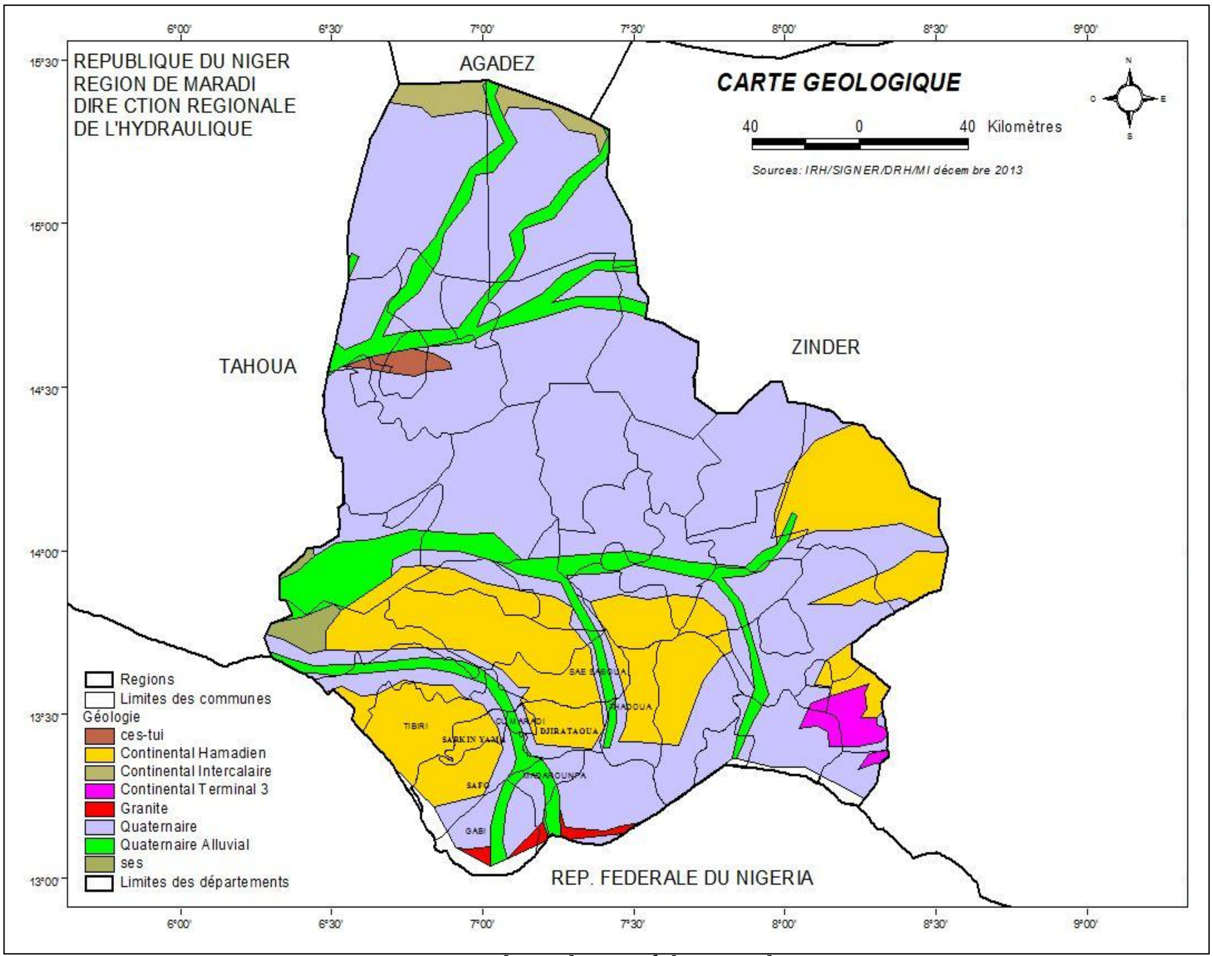

Figure 7: Geological map of the Maradi region

IV. Discussion

The results obtained show that the fluoride ion contents in the borehole waters of the Maradi region are high. According to [19 ,20], these high levels could be due to natural contamination due to hornblende, biotite and cryolite minerals. These results also show that the fluoride ion contents increase with depth at well level than at borehole level. According to the Ministry of Hydraulics of Niger (MHE/Niger), the water reserves in the study area are estimated at several billion cubic meters. These data show that the study area contains significant groundwater resources. According to [21], groundwater can carry 0 to 67.2 ppm of fluorine by dissolving fluorinated rocks in contact with water. Similarly, according to [22, 23, 24, 25], the contact time between fluorinated rocks and deep waters would help facilitate the release of fluoride ions. Figure 7 shows that the rocks outcropping in the study area are made up of granites, aeolian sands, fine fluvial sands, gravels... The lithological logs in Figures 5 and 6 also show that the outcropping formations in the area The study area consists of fine sands, fine gravels and fine clayey sandstone to a depth of approximately 75 m. Indeed, according to Ellis and Mahon, 1964, silicate rocks (essentially formed by silicon with the addition of Al, Mg, Fe, K, Ca, etc.) and the surfaces of crystal grains, release very small quantities of fluorine by leaching from these rocks. Also, according to [21], fluorine is found in silicate minerals because of its lipophilic character. Its similarity in radius and ionic charge with certain elements means that it easily replaces OH- or Cl- ions. However, these results show that, at depths greater than 75 m, the subsoil is essentially formed of shales, clayey sandstones, clayey gravels, siliceous clays, slightly clayey medium sandstones. This vertical succession of facies constitutes the main sequence of aquifers in the study area. The sedimentary clays frequently encountered at depth in the study area would contribute to the fluoridation of groundwater. According to [26], clays are capable of fixing fluorine; and this action would contribute to a fluoridation of the waters in contact with the rocks by dissolution. Also, according to [27], all the fluorine mobilized during weathering is not dissolved in solution in ionic form, but a large part is transported in suspension by the clay fraction contained in geological formations. Similarly, according to [21], the fluoride ion content increases according to the nature of the rock. Thus, in sedimentary rocks, these contents vary from 80 – 450 ppm for sandstone; equal to 270 ppm for limestone; varies from 800 – 900 ppm for gypsum and anhydrite. Also, according to [28], the factors influencing the fluorine content of underground rocks are: the availability and solubility of salts in the rock. However, it is noted that the temperature within a structure increases with the depth of the order of 1°C every thirty (30) meters [29]; and this thermal rise could promote the fluoridation of groundwater in the study area following the increase in depth. According to [30, 31], high temperatures facilitate the release of fluoride ions. Also, according to [30]; high levels of fluoride ions in groundwater may be due to high water temperature. Furthermore, the Maradi region shares the same borders with the Tahoua region.

According to the work carried out by the Inter-African Committee for Hydraulic Studies (CIEH) on geochemical analyses, it appears that the aquifers of the Continental Intercalaire and/or Hamadien cover the entire central band of Niger. However, these aquifers are also shared by the deep aquifer waters of the Tahoua region, which is a phosphate region. In view of the above, it can be said that the fluoride ion contamination of the confined aquifers in the Maradi region could also be linked to contamination from a phosphate deposit.

V. Conclusion

The objective of this study is to determine the impact of the depth of groundwater in the Continental Intercalary and/or Hamadian aquifers on the variations in fluoride ion content in the Maradi region. The results obtained show that the fluoride ion contents are higher in the boreholes than in the well. These results also show that the fluoride ion contents in the waters of the Continental Intercalaire and/or Hamadien aquifers increase with depth. This increase could be due to the dissolution of fluorinated minerals. This indicates an increase in fluoride ion levels at great depth and could expose populations who consume these waters to fluorisis.

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