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Research Article

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Fluorides in the Pre-rif Groundwater and Their Health Risks (Taza, Morocco)

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ABSTRACT

This study includes a survey to estimate the health risks associated with possible exposure to hyper-fluoridated water. This survey aims to determine the groundwater quality in some rural centers of pre-rif of Taza region, focusing on fluorides, and assess the health risks associated with them. A hyper-fluorinated character was revealed in 73% of analyzed water (1.52 to 5.90 mg/L), with some contents which equals 2 to 4 times the guideline value (<1.5 mg/L). The survey among populations using these waters showed that 98% of 52 respondents are in contact with water containing fluoride concentrations above 1.5 mg/L. Thus, 75% of subjects have stained teeth of varying severity, while 17.3% complained of some signs that could be associated with skeletal fluorosis. Furthermore, the survey revealed an ignorance of the population of the problem of fluoride.

Keywords: Fluoride; Quality; Health risks; Groundwater; Pre-rif

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INTRODUCTION

Fluoride is a pervasive element in the lithosphere. It occupies the 17th place among the elements constituting the earth's crust, representing about 0.06 to 0.09% [1]. Most natural waters contain fluorine traces. Excessive levels of fluoride are often characteristics of groundwater [2]. Natural sources that its origin of the fluorine content in these waters depend essentially on the nature of the aquifer rocks (fluorite, apatite, amphibole, mica, albite, biotite…), the contact time between water and fluorinated minerals and chemical control of water. Moreover, the fluoride content

depends on the groundwater chemistry including pH and the concentrations of Na^+, Ca^{2+}, and HCO^{3-} [3-6]. Moreover, we must not overlook the contribution of fluoride from anthropogenic activities, such as using intensive agricultural of phosphate fertilizers (fluorapatite), insecticides or herbicides containing fluoride, the dumping of industrial waste and emissions of fluorinated compounds … [3,7], which are potential sources of fluoride in natural water.

At low concentration, fluorine is a trace element essential to human health. An optimal fluoride intake plays a vital role in the development of tooth enamel, but excessive intake can interfere with the normal formation of enamel of the teeth and bones (fluorosis). In response, WHO has recommended an amount of 0.5-1 mg/L in water intended for consumption, for maximum protection against tooth decay [8], without exceeding the maximum permissible value of 1.5 mg/L [9]. Although drinking water is the main source of fluoride, it must consider other sources of exposure such as beverages high in fluoride, agricultural products and foods prepared with fluoridated water [10]. In addition to dental and skeletal fluorosis, excessive exposure to fluoride can affect other systems; such as the endocrine system which fluorides prove endocrine disruptors, resulting in an increase in thyroid stimulating hormone and calcitonin activity, increased activity of parathyroid hormone, and lowering the level of glucose tolerance which is due to an inhibitory effect of fluorides on the production of insulin [11]. Also some studies have indicated that the exposition to fluoride concentrations more than 4 mg/L can be irritating to the gastrointestinal tract, affecting the tissue and renal function, and alter liver and immunological parameters [12].

Morocco, a country where there is endemic fluorosis in relation to hyper fluorinated ground waters [3], studies of fluorosis and its distribution areas were modeled mainly on fluorotic areas rich in phosphate showing high levels of fluoride in water and other natural matrices, also as bone and dental anomalies that have affected humans and cattle and significant levels of fluoride in plants [13,14]. Nevertheless, fluorosis foci were revealed in regions that poor in phosphate and fluorosis [15].

This study conducted in some douars of 4 rural centers of pre-rif of the Taza region, aims to a comprehensive analysis of the situation of a possible fluoride pollution of its waters and its impact on consumer health. Considering that this area is not known as fluorotic, and to our knowledge, has not benefited from a study of this type.

MATERIALS AND METHODS

Study Area

The study area, which is limited to the right bank of the watershed of Inaouen River, is located in the Pre-Rif marl complex in the North, presenting a low relief and its grounds are clay and marl dominance. The overall structure is related to the thrust of this material whose age and nature are varied (marl, gypsum, limestone and sandstone) [16]. The dominance of these impervious marl formations, show that the study area is devoid of significant underground water reservoirs, except under localized flows and some perched aquifers of very low productivity situated in favorable geological formations (sandstone and marl and limestone) [17]. From the point of view climatology, the study area is characterized by a climate of subhumid. With two distinct and contrasting seasons, a rainy season

which lasted 8 months from October to May, with January as the coldest month, and a dry season from June to September, with July and August as the hottest month [18].

Methods

The sampling, transport, storage and analysis of water samples are made following the protocol of the ONEP water quality control laboratory and the standard standards [19-22].

The centers selected for carrying out the surveys are those characterized by high groundwater fluoride concentration (>1.5 mg/L).

A total of 52 individuals surveyed was selected by simple random sampling. He was excluded from the study any individual not living in selected centers.

The questionnaire was designed to collect information on the history of the individual (duration of possible exposure to high fluoride concentration), age, sex, smoking, eating habits, and to identify the main sources of supply of drinking water.

As it has allowed, firstly, determining the knowledge and attitudes of the individual of fluoride problem, and secondly, to evaluate the risks associated with exposure to water hyper fluoridated. In effect, the severity of dental invasion was identified based on visual interpretation of the teeth of persons (oral communication confirmed by digital images).

RESULTS AND DISCUSSION

Fluorides

Fluoride is naturally present in water, soil, plants, and other living organisms. The natural concentration of F^- in water depends on several factors such as pH, the porosity of the soil and rocks, temperature, etc. [23,24]. For humans, the contribution of F^- mainly comes from drinking water and incidental food and fluoridated toothpaste…..

The evolution of fluoride concentrations (mg/L) in different sampling points, found concentrations ranging between 5.903 mg/L at the source S1 and 0.562 mg/L at P4 (Figure 1).

These results show that 27% of samples have contents located within the range of recommended levels in waters drink, to have a beneficial effect of the fluoride ion (0.5-1 mg/L) [8] and benefit its carioprotection share. While, more than half of the points (73%) have fluoride levels that exceed the maximum recommended value for the drink waters [9,25], recording values ranging from 1.52 to 5.90 mg/L. Indeed, some of these points with values may be equal to 2 almost 4 times the guideline value.

An excessive fluoride intake can affect the normal formation of teeth and bones. However, its consumption at high doses (>1.5 mg/L) leads to dental fluorosis. At higher doses (>3 mg/L) fluoride can cause skeletal fluorosis [12].

In general, fluoride content between 1.5 and 2 mg/L leads to dental conditions and, in advanced stages, leads to dental fluorosis [12]. Indeed, it has been shown that the prevalence and severity of dental fluorosis increase with the fluoride concentration in drinking water [26].

When the fluoride concentrations in drinking water exceed 4-8 mg/L, skeletal fluorosis may appear manifesting by an increase in bone density, bone pain and calcification of ligaments [12]. As it was found that consumption of

fluoridated water to 4 mg/L during a lifetime could have the potential to induce skeletal fluorosis stage 2 or 3 and increase the risk of bone fracture [11]. As has been reported that exposure to fluoridated water between the ages of six and eight years for boys, significantly increases the number of osteosarcoma at the beginning of the twenties [26].

The fluorosis severity depends on the fluoride concentration in drinking water, the daily dose, continuity and duration of exposure, and the weather [12].

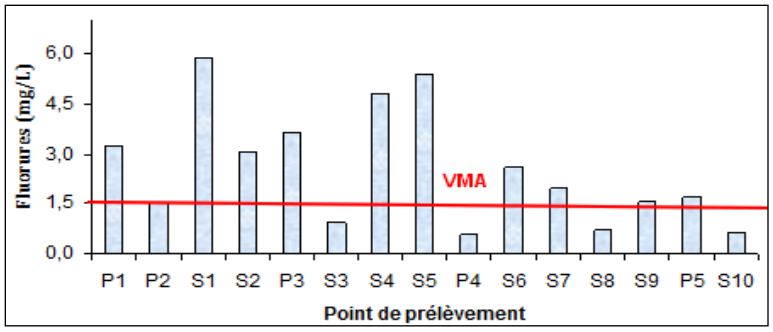

Figure 1. Variation of fluoride levels (mg/L) of groundwater in the Pre-rif in the Taza region

Survey Results

The surveyed population (52 individuals) is evenly distributed between sexes (50% of women against 50% of men). The weights of surveyed age groups correspond to the following distribution: 2 to 12 years account for 15.4%, 13 to 18 for 17.3%, 19 to 25 for 30.8%, 26 to 55 years for 28.8% and over 55 years for 7.7%.

Fluoride Exposure

The calculation of population contact time with the fluorides shows that the average exposure time is 20 years (with a minimum of 2 years and a maximum of 75 years).

The identification of sources of domestic water for each subject reveals that 98% of the 52 individuals surveyed are in contact with fluoride levels above 1.5 mg/L (drinking, cooking ...). Indeed, the survey data indicated that each inhabitant consumes an average 3 L/day of water from groundwater sources (min=0.75 and max=5 liters).

If we calculate the daily intake of fluoride through water consumption, taking into account the body weight of the subject and the fluoride concentrations in the water, the values obtained are much higher than the acceptable daily dose (0.05 mg/kg/j) [27].

As for other sources of fluoride intake (Figure 2), 100% of the respondents say they take foods rich in fluorine, such as fish and tea. In fact, tea is the main beverage of Moroccan, as it is the plant known by these high levels of fluoride.

Knowledge of Fluorides

As for knowledge and attitudes towards the fluorides: 94.2% of respondents have never heard of fluoride, and less than 2% are able to identify the signs associated with the fluorides ingestion.

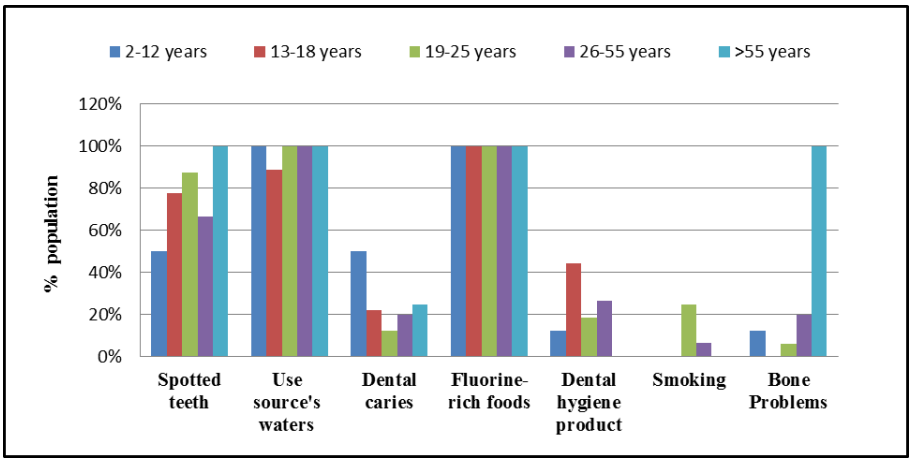

Figure 2. Exposure Factors and dental and bone disease by age group

Health Data

Dental disease: Dental fluorosis, which is due to excessive fluoride during tooth development, has been identified in 75% of subjects. While the absence of teeth mottled was marked with the remaining 25%, 21% spent their childhood in other regions and inhabited the douars involved in the study at advanced ages after the period of tooth development.

All surveyed age groups seem to be affected with varying proportions (Figure 2).

The observed tasks vary in severity from opaque tasks whitish brown to blackish tasks involving some teeth and sometimes the majority of teeth (incisors, canines, premolars ...), which provides informations on the different stages of disease development (Figure 3).

Figure 3. Subjects with dental fluorosis of varying gravity

Bone disease: The results of the survey show that 17.3% of individuals have clinical signs that could be associated with bone fluorosis.

The most frequent complaints are bone pain, arthralgia, diffuse algia, joint stiffness and sometimes limitation of movements.

The proportion of people with these clinical signs increases with the age group; in fact, it is 100% in the group over 55 years (Figure 2).

However, these results cannot be conclusive. Due to the aspecific nature of the clinical signs of bone involvement, it is necessary to perform para-clinical (biological and radiological) investigations which, in combination with the clinical diagnosis, provide a formal diagnosis of bone fluorosis.

CONCLUSION

This work revealed the presence of fluoride levels well above the recommended value (<1.5 mg/L) in 73% of the points. In fact, some points have values ranging from 2 to 4 times the guideline value. As it enabled us to determine the extent of the impact of the intake of these fluorides on the health of the population exposed to these concentrations, this was expressed mainly by dental injuries of variable gravity.

To overcome this problem and deal with this situation, several measures have to be implemented for these populations. Among others:

- Conduct deeper studies and widen the investigation (to delineate the entire area affected by this fluoride problem) in order to explore the possible presence of other pollutants in groundwater, as well as their health risks linked to a long exposure. By highlighting the interaction between environment and health.
- Sensitize and inform these populations about water quality, its preservation, and the protection of various groundwater points.
- In order to avoid intake of high levels of fluorides, it is advisable to use the water less contaminated for drinking water (avoid contaminated sources), to vary these sources or to boil its waters.
- The appearance of dental fluorosis can be avoided by protecting children from pregnancy to the age of 8 years.
- Inform the population of the importance of adopting drinking water measures at home.

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