An epidemiological study of geographical mapping of fluoride levels in drinking water in the north-western region of Libya

Abdullatef A. M. Nureddin[1] and Abdulbaset Shagan[2]

[1]Department of Oral Surgery, Oral medicine and Oral pathology, Faculty of Dentistry, University of Tripoli, Tripoli and [2]Department of Orthodontia, University of Zawia, Zawia, Libya
Correspondance: Nureddinabdullatef@yahoo.com.

Abstract: Fluoride has beneficial effects on teeth at low concentrations in drinking water, but excessive exposure to fluoride in drinking water can give rise to adverse effects ranged from dental fluorosis to crippling skeletal fluorosis. As knowledge of fluoride level in drinking water is of importance in dental and skeletal health, yet this information is lacking, at national level, in Libya. Therefore, the aim of this study is to reveal out the accurate information through drinking water quality, analysis and scientific study of fluoride distribution which are necessary to understand sources and levels of fluoride contamination. Water samples were collected from government ground water supply from different regions in the north-western districts. The fluoride concentration was determined using a Lanthanum Fluoride Ion Selective Electrode. The fluoride level was in the range of 0.01 and 3.9 ppm respectively. In general, the fluoride level in the north-western Libyan districts drinking water supplies is above the WHO recommended level of 0.7 ppm in hot climate countries. It is, therefore, recommended water fluoridation must not be considered in drinking water supply.

Keywords: geographical mapping, drinking water, fluoride, water fluoridation.

Introduction

Fluoride has been described as an essential element needed for normal development and growth of human. Fluoride is abundant in the environment and the main source of fluoride is drinking water, in which it is typically the largest single contributor to daily fluoride intake (1). Exposure to public water suppliers of 1 ppm fluoride concentration in temperate countries has been shown to reduce dental caries incidence by approximately 50% (2), when fluoride concentration exceeds 1 ppm, fluoride causes mottling of teeth (dental fluorosis). Dental fluorosis is a reflection of fluoride exposure prior to eruption of teeth due to increase fluoride concentration in the extra-cellular fluid surrounding the tooth during its development, while the degree of fluorosis is depending on the total fluoride dose, time and duration of fluoride exposure (3), while prolonged consumption of well water with more than 4 pp and habitual consumption of large amount of extra strength instant black and green tea play an etiological role in development of skeletal fluorosis which characterized by marked limitation of the joint movements, considerable calcifycation of ligaments, crippling defor-

mities of the spine, muscular wasting and neurological defects associated with compression of spinal cord (4, 5).
Fluoride in naturally occurring water can be above, at, or below recommended levels. Rivers and lacks generally contain fluoride levels less than 0.5 mg/L, but ground water, particularly in volcanic or mountainous areas can contain fluoride above the recommended level. Higher fluoride concentrations are found in alkaline volcanic, hydrothermal, sedimentary, and other rocks derived from highly evolved magmas and hydrothermal solutions (6).

In hot climate countries like Libya, the appropriate level of fluoride concentration in drinking water as recommended by WHO should be 0.6-0.7 ppm, while in cool climate countries where the consumption of water is relatively low is 1.2 ppm (7). A part from drinking water, vegetables and fruits normally have low levels of fluoride range between 0.1-0.4 mg/kg, rice 2 mg/kg, meat 0.2-1.0 mg/kg, fish 2-5 mg/kg, bone of canned fish such as sardines 370 mg/kg, milk and milk products 0.01-0.8 mg/l and beverages 0.21-0.96 mg/l (8). However, in general diets appear to contribute only slightly to the total daily fluoride intake (9).

Materials and methods

Geography of Libya: Libya is located at the midpoint of African's northern rim, with an area of 1,760,000 square Kilometers in size and a Mediterranean coastline of nearly 1,800 Kilometer long.

The Mediterranean and the Sahara desert are the country's most prominent natural features. In most of the coastal low land, the climate is Mediterranean with warm summers, mild winters and scanty rainfall, while in the desert the climate has a very hot summers and extreme diurnal temperature. Deficiency in rainfall is reflected in an absence of permanent rivers or streams and the approximately twenty perennial lakes are brackish or salty (10). Therefore, the source of drinking water is dependent on the ground water.

Study area: The study area, Jifarh plain of Tripolitania, a triangular area of some 15,000 square Kilometers located at the north-western region of Libya. It lays in between N32 degree 45 and N32 degree 57 North latitudes and E14 degree 18 and E11 degree 54 East longitudes. The study area is bounded by the Mediterranean coast of about 250 Kilometer long, starting from Alkhoms city to Ras-Egdeer, the border point between Libya and Tunisia and terminates in an escarpment that rises to form the Nafusah mountain, a plateau with elevations of up to 1,000 meters (Figs. 1, 2, 3). This area comprise about five districts, small part of Almerqab district, Tripoli district, Alzawiyh district, Aljifarh district and Zuwarh district (11). The normal annual rainfall over these districts varies from 400 mm to 600 mm. The study area enjoys the Mediterranean climate. The periods from June to Augustus are generally hot and dry (summer) and it is pleasant during December to February (winter).

Fig. 1: Map of Libya

Fig. 2: Regions of Libya

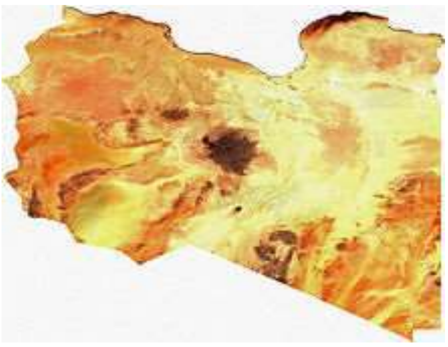

Fig. 3: Geographical details of Libya

Collection of water samples: The sampling frame is designed according to the main underground water reservoirs in this region as mapped in the Libyan geographical Atlas produced by Ministry of planning in 1978 (12), with disregarding to the borders of districts. There are four main water reservoirs. The first underground water reservoir is relatively small and located mainly under the center of the capital Tripoli, and termed (RV1). The second reservoir is a large one which starting from Alkhmas passing down to Al-Azizia district, surrounded the Tripoli central zone and extended to Alzawia district. This zone is termed (RV2). The third reservoir present in Zawara district and termed (RV3). The fourth reservoir extended from nearby Zwara city to the border between Libya and Tunisia. This zone is excluded from this study due to high mineral contents (more than 5000 mg/l) (12), that it is not used for drinking (12).

A total of 20 ground water samples were collected from governmental ground water supply. Six samples from RV1, 10 samples from RV2, and 4 samples from RV3, use plastic bottles of 1,000 ml. The bottles were rinsed 3 times with the source of water before sample collection. The bottles were tightly capped to protect samples from atmosphere CO_2, adequately labeled and stored at 4-8 ^{o}C, then analyzed within 72 hours of sampling in the Institute of Oil Research in Tripoli. The fluoride concentration was determined on the unfiltered water samples using a Lanthanum Fluoride Electrode (Orion Model 94-09) with a reference electrode (Orion Model 407A), both samples and standard were 1 : 1 diluted with TISAB II (Orion Total Ionic Strength Adjustment buffer II). Fluoride concentration was read off directly from the ion meter after calibration with two fluoride standards (13).

Fig. 4: Districts of western region of Libya

Fig. 5: Geographic distribution

Statistical analysis: Analysis of variance (ANOVA) and t-test were used to determine the significance of the difference between fluoride concentration in various drinking water sources in different geological underground water reservoirs.

Results

A summary of the results of fluoride concentration in the underground drinking water of the north-western region of Libya (Jifarh Plain of Tripolitania) is presented in Tables 1, 2, 3 and 4. Table 1 shows the fluoride concentration in RV1, the water reservoir that located under the center of the capital Tripoli.

Number of samples	F- Concentration ppm	Median	Mean
1	0.49		
2	0.49		
3	0.49	0.49	0.52
4	0.49		
5	0.59		
6	0.53		

Table 1: Fluoride concentration in RV1

It is observed that in this zone the different water samples have similar fluoride level and the fluoride concentration of all the samples were slightly below the normal limit (0.6-0.7 ppm) that recommended by WHO (6). The fluoride level ranges from 0.49-0.59 ppm with a mean of 0.51, median 0.49 and standard deviation 0.041.

Table 2 shows the fluoride concentration in the second underground water reservoir (the largest zone) that supply drinking water for most of the population in this plain. Generally, the fluoride concentration in the various water samples from this zone (RV2) were significantly higher than in the first zone (RV1) ($p \leq 0.05$).

No. of samples	F – conc, ppm	Median	Mean
1	0.78	1.52	1.43
2	1.19		
3	1.28		
4	1.32		
5	1.51		
6	1.52		
7	1.6		
8	1.63		
9	1.65		
10	1.83		

Table 2: Fluoride concentration in RV2

No. of samples	F – conc., ppm	Media	Mean
1	1.84	2.15	2.51
2	2.o9		
3	2.21		
4	3.9		

Table 3: Fluoride concentration in RV3

All the water samples from different underground governmental water supply showed a high fluoride concentration above the normal limit of WHO. It is interesting also, the fluoride level in the various samples vary slightly between them. The fluoride level ranges between 0.78 and 1.83 ppm with a mean of 1.43, Median 1.52 and Standard deviation 0.30. It is clear that this zone shows nearly about two times as high as the level of fluoride concentration recommended by WHO in drinking water in hot climate countries.

Table 3 showed fluoride concentration in the third underground water reservoir (RV3). It is statistically significant to note that this zone has the highest fluoride concentration when compared to the first (RV1) and the second (RV2) zones ($p \leq 0.05$).

The fluoride concentration is about 3 times higher than the normal limit. It ranges between 1.84 to 3.9 ppm, with mean 2.51 ppm, Median 2.15 and standard deviation of 0.94. The differences between the fluoride concentrations of the various zones are demonstrated in Table 4. Furthermore, and as shown in table 5, the sources of drinking water, generally, in Tripolitania underground reservoirs was higher than the normal limits, the mean was 1.37 ppm and standard deviation 0.83.

Samples	Range (Min-Max) F-ppm	Mean ± S.D F- ppm	% Samples with F- concentration More than 0.7 ppm	Number of samples
Samples from RV1	**0.49 - 0.59**	**0.51 ± 0.041**	**_**	**6**
Samples from RV2	**0.78 - 1.83**	**1.43 ± 0.30**	**10**	**10**
Samples from RV3	**1.84 - 3.9**	**2.5 ± 0.94**	**4**	**4**
Total	**-**	**-**	**14**	**20**

Table 4: Fluoride concentration in RV1, RV2 and RV3

Number of samples	F- Concentration ppm	Number of samples	F- Concentration ppm
1	0.49	12	1.52
2	0.49	13	1.6
3	0.49	14	1.63
4	0.49	15	1.65
5	0.53	16	1.83
6	0.59	17	1.84
7	0.78	18	2.o9
8	1.19	19	2.21
9	1.28	20	3.9
10	1.32	Mean	1.37
11	1.51	Standard deviation	0.83

Table: 5 Fluoride concentrations in Tripolitania ground water

Discussion

The study has revealed the generally high fluoride concentration of undergr-ound drinking water system in the North-Western Region of Libya. None of the twenty water samples collected from this region had fluoride level less than 0.49 ppm. About 70% of all water samples studied had fluoride concentr-ation more than the level (0.6-0.7 ppm) that recommended by World Health Organization (WHO) for hot climate countries where the consumption of ater is relatively high (6) instead of cool climate countries where the cons-umption of water is relatively low, the fluoride level should be 1.2 ppm (7). The other 30% of water samples were slightly below the normal limit, which ranged between 0.49 ppm and 0.59 ppm with mean of 0.51. This level of fluoride in this study has seen only in the first underground water reservoir that located under the center of the capital Tripoli with a borders of about 10 km west, 15 Km east and 20 km south the center of Tripoli.

References

1. Dahr V, Bhatnagar M (2009) Physiology and toxicity of luoride. Indian J Dental Res 20, 3: 350-355.
2. Murray JJ, Rugg-CunnAJ (1982) Fluoride in caries prevention. Dental practitioner hand book No. 2nd ed. Bosten: Wright PSG, Modes of action of fluoride reducing caries; pp222-223.
3. Cocharn JA et al. (2004) A comparison of the prevalence of fluorosis in 8-years-old children from seven European study sites using a standard methodology. Community Dent. Oral Epidemiol. 32S 1: 28-33.
4. Whyte et al. (2008) Skeletal fluorosis from instant tea. J Bone Miner Res. 23, 5: 759-769.
5. Reddy DR (2009) Neurology of endemic skeletal fluorosis. Neural India 57, 1: 7-12.
6. Fawell et al. (2006) Fluoride in drinking water. WHO. Int/water sanitation health/publication/ fluoride drinking water full pdf. WHO. ISBN 92-4-156319-2. Environmental occurrence, geochemistry and exposure. pp. 5-27.
7. Khan NB and Chohan, AN (2009) Accuracy of bottled drinking water label content. Environ Monit Assess. URL, Doi. Org./10.1007/a10661-009-0993-7.
8. WHO (2006) Fluoride in drinking water. Fawell J, K Bailey, J Chilton, E Dahi, L Fewtrell and Y Magara. ISBN: 1900222965.
9. Murry JJ (1986) Appropriate use of fluorides for human health. World Health Organization, Geneva.
10. Countrystudies.us/Libya/3.5.htm, (www).
11. Citypopulation.de/Libyan.htm, (www).
12. Geographical Atlas of Libya. Produced by Ministry of planning 1978. P o Box 600 Tripoli. Drawn by Islets company. Stockholm. Sweden.
13. Orion Research (1967). Instruction manual : Fluoride Electrode Model 94-09, Orion Res. Cambridge, USA.