

Original Article

Investigation of Fluoride Level in Drinking Water Supplies of Qaemshahr City (North of IRAN) from 2006 to 2012

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Abstract

Background and purpose: Fluoride is one of the fundamental and required components in human body. The current study intends to survey the status of fluoride in drinking water supplies (underground water source and drinking water) in Qaemshahr city from 2006 (march/21) to 2012(march/19) and comparison with universal standards, national and climatic conditions.

Materials and Methods: This is a descriptive and sectional study. Samples were experimented in Qaemshahr water and wastewater department laboratory. Fluoride concentration in samples has been measured by DR 2800 and SPADNS Fluoride Reagent Solution. Results were analyzed with Excel software. The medium of maximum temperature in different seasons has been obtained from meteorology department. Then fluoride levels in several years have been compared to each other and to universal, national and climatic standards.

Results: Comparing to standards National standards of IRAN and according to climatic conditions, proper levels of fluoride were in underground water sources respectively (9 % - 0.9 %) in spring, (17 % - 6.5 %) in summer and, (13 % - 0.00 %) in autumn and in winter. Also in Urban water distribution network were respectively (3.2 % - 3.2 %) in spring, (12.5 % - 5 %) in summer, (8.3 % - 0.00 %) in autumn and, (0.00 % - 0.00 %) in winter. The Fluoride levels in 100% of samples were lower than standards (MCLG and MCL= 4 mg/l).

Conclusion: No significant relation was observed between fluoride concentrations obtained in different seasons and in different years. In most cases the Fluoride levels in studied city were lower than universal standards, national and climatic conditions. It is recommended that adding fluoride to food chain of the studied citizens should be noticed by the relevant authorities.

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Key words: Fluoride, drinking water supplies, Qaemshahr, Iran

1. Introduction

Fluoride is one of the fundamental and required components in human body. Fluoride concentration in underground water may arrive to several mg/lit because they transmit the fluoride-rich parts (7). Fluorine is the lightest member of the halogen group and is one of the most reactive of all chemical elements. So, it is not found as fluorine in the environment. The first WHO publication dealing specifically with drinking-water quality was published in 1958 as international standards for drinking-water. It is found in all natural water at some concentration. In groundwater, however, low or high concentration of fluoride can occur, depending on the nature of rocks, occurrence of fluoride and bearing of minerals. Concentrations in water are limited by fluorite solubility. Fluoride in drinking-water will be an invaluable reference source for all those concerned with the management of drinking-water containing fluoride and the health effects arising from its consumption, including water sector managers and practitioners as well as health sector staff at policy and implementation levels (7). Indeed, more than 10 million people in china are reported to suffer from fluorosis, related in part to the burning of high fluoride coal (8). The composition of the diet influences retention of dietary fluoride (20). Fluoride has beneficial effects on teeth at low concentrations in drinking-water, but excessive exposure to fluoride in drinking-water, or in combination with exposure to Fluoride from other sources, can give rise to

a number of adverse effects(7). Fluoride is one of the drinking-water contaminants regulated by EPA. Fluoride may be found in drinking water as a natural contaminant or as an additive intended to provide public health protection from dental caries (artificial water fluoridation)(17). Fluoride gets accumulated in hard tissues of the body and has been know to play an important role in mineralization of bone and teeth. At high levels it has been known to cause dental and skeletal fluorosis (5). Higher levels of fluoride have been found in barley and rice (e.g. about 2 mg /kg) .In general, the levels of fluoride in meat (0.2 - 1.0 mg / kg) and fish (2-5 mg/kg) are relatively low. The problem of high fluoride concentration in groundwater resources has become one of the most important toxicological and geo-environmental issues in India. World Health Organization guideline value and the permissible limit of fluoride as per Bureau of Indian Standard (BIS) is 1.5 mg/l (14). Guideline value (Min and Max) are 0.5 and 1.5 mg/l .The amounts added to drinking-water are such that final concentrations are between 0.5 and 1 mg/l. The fluoride in final water is always present as fluoride ions, whether from natural sources or from artificial fluoridation. The protective effects of fluoride increase with concentration up to about 2 mg of fluoride per litre of drinking-water; the minimum concentration of fluoride in drinking-water required to produce it is approximately 0.5 mg/l. It was emphasized that in setting national standards for fluoride,

it is particularly important to consider climatic conditions, average annual temperature, Protectors of teeth, volume of water intake and intake of fluoride from other sources (food,air,.) (10). Allowable fluoride concentration in drinking water increase when the temperature of climate decrease; it is because of high consumption of water in high weather (7). The fluoride proper concentration in drinking water is determined based on the region temperature. The current study intends to survey the status of fluoride in underground water source and drinking water in Qaemshahr city from 2006 (march/21) to 2012(march/19) and comparison with universal standards, national and climatic conditions.

Materials and Methods

2.1 Site study & Sampling strategy

Mazandaran province is in the north of IRAN. Qaemshahr city is situated 237 kilometres (147 mi) north-east of Tehran; 20 kilometres (12 mi) southeast of Babol; and 23 kilometres (14 mi) south west of Sari which is the capital of Mazandaran province. The Covered Population Qaemshahr city is 209920 people (2012 year -urban). The current study intends to survey the status of fluoride in drinking water supplies (underground water source and drinking water) in Qaemshahr city from 2006 (march/21) to 2012(march/19) and

comparison with universal standards, national and climatic conditions. This is a descriptive and sectional study. Qaemshahr city has twenty-two water wells for water supply wells which some of these wells are inactive off and on. In every seasons of year water samples were taken from active water wells to determine the fluoride levels. Minimum five Samples have been selected according to distribution network status randomly. In fact, Samples have been selected from active water wells and urban water distribution network from 2006 to 2012 through accidental method. Samples were experimented in Qaemshahr water and wastewater department laboratory. Fluoride concentration in samples has been measured by DR 2800 and SPADNS Fluoride Reagent Solution. Results were analyzed with Excel software. Since fluoride is determined according to ambient temperature, To determine the optimal amount of fluoride and local standards, average maximum daily temperature in seasons (from 2006 to 2012) were received from Mazandaran Meteorology Organization. The suggested fluoride concentration for fluorideated water supply system can be estimated from (7):

$$F \text{ (mg/l)} = 0.34 / 0.038 + 0.0062 T^{\circ f}$$

Then fluoride levels in several years have been compared to each other and to universal, national and climatic standards.

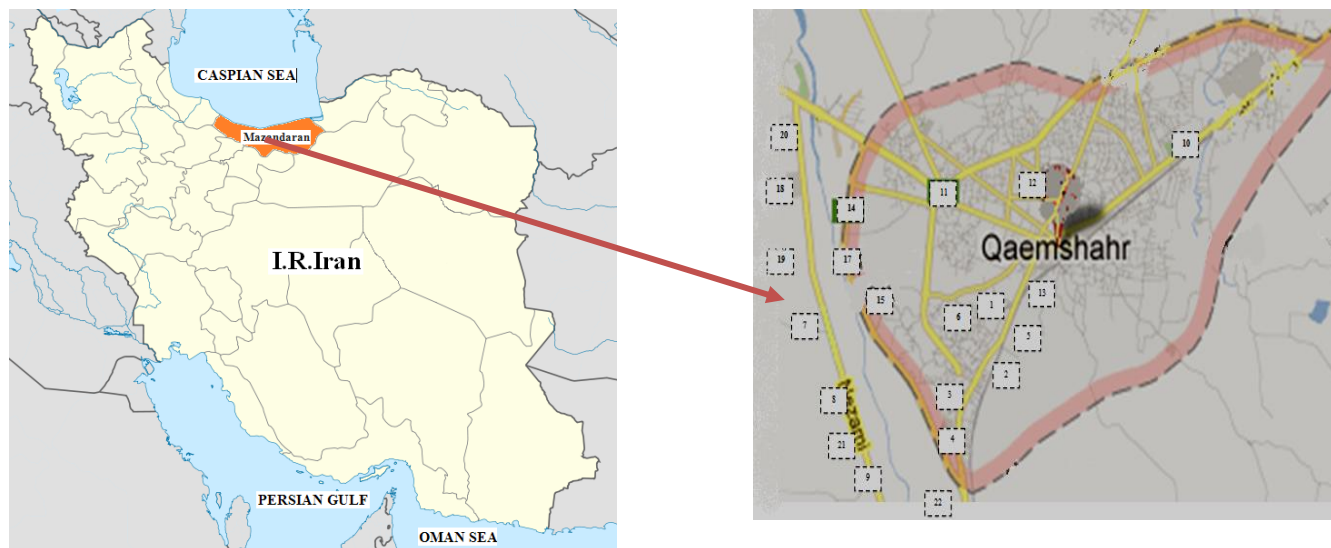


Fig 1. Sampling location

3. Results

The maximum, the minimum and mean levels of fluoride were (0.01, 0.67 and 0.31 ± 0.14 ppm) in Spring, (0.00, 0.78 and 0.32 ± 0.16 ppm) in Summer, (0.01, 0.63 and 0.29 ± 0.15 ppm) in Autumn, (0.01, 0.67 and 0.28 ± 0.16 ppm) in Winter and (0.00, 0.78 and 0.30 ± 0.15 ppm) in total years respectively and these measures has been obtained from 439 samples of underground water sources (deep well) during 6 years. (0.06, 0.68 and 0.28 ± 0.11 ppm) in spring, (0.06, 0.68

and 0.32 ± 0.14 ppm) in Summer, (0.01-0.61 and 0.26 ± 0.15 ppm) in Autumn, (0.01, 0.48 and 0.25 ± 0.13 ppm) in Winter and (0.01, 0.68 and 0.28 ± 0.14 ppm) in total years were the maximum, minimum and mean levels of fluoride and has been obtained from 137 samples in Urban water distribution network respectively and (Table1). Fluoride concentrations (ppm) in underground water sources and in urban water distribution network are according to Table 3 and 4.

Table 1. Maximum, Minimum and Mean levels of fluoride concentrations (ppm) in Urban water distribution network & underground water sources in Qaemshahr city (2006-2012)

Season	Spring		Summer		Autumn		Winter		TOTAL	
	sources	network	sources	network	sources	network	sources	network	sources	network
N	113	31	123	40	95	36	108	30	439	137
Mean	0.31	0.28	0.32	0.32	0.29	0.26	0.28	0.25	0.30	0.28
SD	0.14	0.11	0.16	0.14	0.15	0.15	0.16	0.13	0.15	0.14
Min	0.01	0.06	0.00	0.06	0.01	0.01	0.01	0.01	0.00	0.01
Max	0.67	0.68	0.78	0.68	0.63	0.61	0.67	0.48	0.78	0.68

Table 2. Suggested fluoride concentration for fluoridated water supply system according average maximum daily temperature in seasons (ppm) in Qaemshahr city (2006-2012)

Year	2006-7		2007- 8		2008- 9		2009-10		2010-11		2011-12	
	T °f	F ⁻	T °f	F ⁻	T °f	F ⁻	T °f	F ⁻	T °f	F ⁻	T °f	F ⁻
Spring	74.52	0.68	73.35	0.69	76.96	0.66	71.11	0.71	74.52	0.68	74.52	0.68
Summer	90.08	0.57	86.82	0.59	88.42	0.58	85.27	0.60	90.08	0.57	86.82	0.59
Autumn	70.04	0.72	67.98	0.74	66.99	0.75	68.99	0.73	73.35	0.69	64.18	0.78
Winter	56.19	0.88	53.48	0.92	56.90	0.87	57.64	0.86	55.49	0.89	52.84	0.93

Table 3. Fluoride concentrations (ppm) in underground water sources in Qaemshahr city(2006-2012)

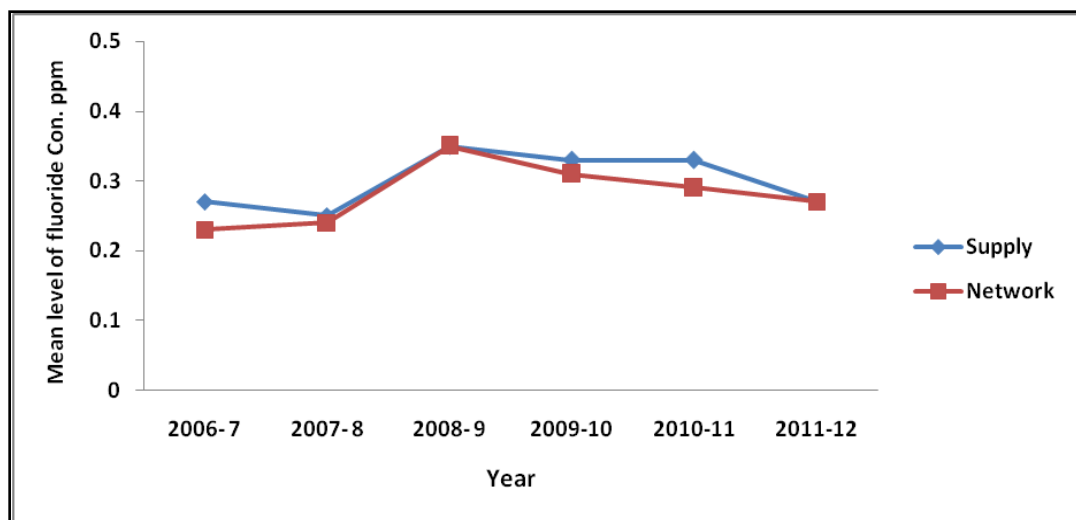
Season	Spring						Summer						Autumn						Winter					
	2006-7	2007- 8	2008- 9	2009-10	2010-11	2011-12	2006-7	2007- 8	2008- 9	2009-10	2010-11	2011-12	2006-7	2007- 8	2008- 9	2009-10	2010-11	2011-12	2006-7	2007- 8	2008- 9	2009-10	2010-11	2011-12
N	19	19	17	19	19	20	19	20	22	20	21	21	12	9	17	17	20	20	14	20	17	17	20	20
Mean	0.35	0.31	0.24	0.41	0.25	0.27	0.36	0.24	0.40	0.32	0.39	0.24	0.19	0.21	0.39	0.26	0.37	0.25	0.14	0.21	0.34	0.33	0.32	0.31
SD	0.14	0.10	0.15	0.13	0.14	0.11	0.22	0.06	0.12	0.17	0.16	0.11	0.17	0.18	0.15	0.11	0.14	0.08	0.09	0.11	0.18	0.16	0.15	0.16
Min	0.06	0.17	0.10	0.10	0.01	0.11	0.00	0.15	0.16	0.02	0.03	0.00	0.01	0.01	0.20	0.05	0.07	0.10	0.01	0.01	0.05	0.08	0.10	0.10
Max	0.54	0.52	0.67	0.61	0.50	0.48	0.78	0.33	0.65	0.62	0.59	0.53	0.53	0.45	0.63	0.50	0.59	0.38	0.30	0.45	0.60	0.67	0.63	0.67

*Total number of 22 water well

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Table 4. Fluoride concentrations (ppm) in Urban water distribution network in Qaemshahr city (2006-2012)

Season	Spring					Summer					Autumn					Winter								
Year	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12
N	5	3	3	5	7	8	5	6	5	8	7	9	6	5	5	8	6	6	3	4	2	7	7	7
Mean	0.28	0.33	0.26	0.33	0.25	0.24	0.37	0.22	0.32	0.40	0.38	0.26	0.10	0.22	0.43	0.28	0.32	0.04	0.24	0.38	0.25	0.21	0.36	
S D	0.14	0.08	0.14	0.08	0.11	0.06	0.16	0.09	0.12	0.13	0.09	0.14	0.10	0.13	0.12	0.12	0.19	0.05	0.03	0.06	0.10	0.17	0.08	
Min	0.01	0.24	0.10	0.20	0.06	0.13	0.23	0.06	0.21	0.29	0.26	0.10	0.02	0.03	0.31	0.01	0.09	0.12	0.01	0.17	0.31	0.02	0.11	
Max	0.68	0.39	0.37	0.40	0.37	0.31	0.58	0.29	0.52	0.68	0.48	0.50	0.25	0.35	0.61	0.40	0.60	0.27	0.06	0.31	0.45	0.46	0.31	

**Fig 2.** Mean levels of fluoride concentrations (ppm) in Urban water distribution network & underground water sources in Qaemshahr city (2006-2012)

4. Discussion

The Maximum Contaminant Level Goal (MCLG) and The Maximum Contaminant Level (MCL) for fluoride are 4 mg/l (ppm) also Secondary Drinking Water Regulations (SDWR) is 0.2 mg/l (EPA 2012). Guideline value (Min and Max) are 0.5 and 1.5 mg/l. The amounts added to drinking-water are such that final concentrations are between 0.5 and 1 mg/l.

The fluoride in final water is always present as fluoride ions, whether from natural sources or from artificial fluoridation. The protective effects of fluoride increase with concentration up to about 2 mg of fluoride per litre of drinking-water; the minimum concentration of fluoride in drinking-water required to produce it is approximately 0.5 mg/l.

It was emphasized that in setting national standards for fluoride, it is particularly important to consider climatic conditions, average annual temperature, Protectors of teeth, volume of water intake and intake of fluoride from other sources (food, air , ...) (10). The average annual mean maximum temperatures (AMMT) of Pakistan is 29°C at which the optimal fluoride in drinking water of Pakistan was calculated to be 0.7 ppm (12). The investigation has confirmed that the maximum allowable concentrations (MAC) of fluorides is exceeded in the artesian waters of the Moscow Region (13). Fluoride concentration was 0.2 to 9.2 mg/l(11). Results indicated that water supply from 42% of the municipalities had a fluoride concentration over the Mexican standards of 1.5 mg/l(9). Fluoride content ranged between 0.01 and 9.35 mg/l(4). Fluoride levels were low in most parts of the country, being 0.3 ppm or less in 62% of the local government areas(1). Incidence of dental, skeletal and crippling skeletal fluorosis was reported in India with average fluoride concentrations as low as 0.5, 0.7 and 2.8 ppm respectively (2). The average fluoride concentration for this region was recorded 2.82 mg/l(19). Fluoride concentrations were blow WHO drinking water standard limits (0.7 – 2.0 mg/l) in the Karaj and Jajrud Rivers respectively (3). At nationwide level, the portion of extracted groundwater with fluoride concentration lower than the minimum permissible level of 0.5 mg/L, desirable fluoride range of 0.5–1.5 mg/L and elevated fluoride level was 69.2, 29.3 and 1.4%, respectively(15).

Comparing to standards National standards of IRAN and according to climatic conditions, proper levels of fluoride were in underground water sources respectively (9 % - 0.9 %) in spring, (17 % - 6.5 %) in summer and, (13 % - 0.00 %) in autumn and in winter. Also in Urban water distribution network were respectively (3.2 % - 3.2 %) in spring, (12.5 % - 5 %) in summer, (8.3 % - 0.00 %) in autumn and, (0.00 % - 0.00 %) in winter. The Fluoride levels in 100% of samples were lower than standards (MCLG and MCL= 4 mg/l) (Table 2.3.4). The results showed that fluoride concentration in different seasons during these six years were as follows: (Summer> Spring> Autumn> Winter) (Table 1). Also suggested fluoride concentration should be according to average maximum daily temperature in Qaemshahr city for fluoridated water supply system (summer> spring> autumn> winter).

But no significant relation was observed between fluoride concentrations obtained in different seasons and in different years. Fluoride concentrations in Urban water distribution network were lower than underground water sources (Table 3,4 and fig 2), it may be related to type of pipe material, secondary contamination, distance and etc. According to the results in most cases the Fluoride levels in studied city were lower than universal standards, national and climatic conditions. It is recommended that adding fluoride to food chain the studied citizens should be noticed by the responsible authorities.

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