CHILD DENTAL CARIES IN RELATION TO FLUORIDE AND SOME INORGANIC CONSTITUENTS IN DRINKING WATER IN ARSANJAN, IRAN

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Summary: This study was conducted to determine the relationship of fluoride (F) in groundwater and dental caries in children living in the Arsanjan area of the Fars province, Iran, and also with some inorganic constituents in the water. Eight villages in Arsanjan with only groundwater sources of drinking water and essentially the same socio-economic living standards and nutritional conditions were surveyed. All 2376 children of all the villages in the three age groups of 6 (5.5–6.5), 9 (8.5–9.5), and 11 (10.5–11.5) years were examined. The F content in the village drinking water measured by the SPADNS method ranged from 0.1 to 1.2 mg/L. Besides pH, alkalinity, and total dissolved solids (TDS), the levels of Cl^-, SO_4^{2-}, Ca^{2+}, and Mg^{2+} were also determined. The overall number of decayed permanent teeth (D_t) per child ranged between 0.12 and 0.36 and the number of decayed deciduous teeth (d_t) ranged between 1.01 and 3.30 per child. Linear regression analyses showed only a weak but no significant association between small decreases of the mean overall D_t and d_t and increasing water F levels. However, F was positively related to TDS, Ca^{2+}, and Mg^{2+}, but negatively related to pH with no other association between the F concentration and other parameters.

Keywords: Arsanjan, Iran; Child dental caries; Inorganic constituents; Water fluoride levels.

INTRODUCTION

Excessive consumption of fluoride (F) is known to cause a wide range of adverse health effects,[1-5] and F in drinking water is often the main source of F intake. It is important therefore to determine potential effects of drinking water F level on health, and this has been an essential undertaking in many countries.[6-10] In the present study we examined the relationship between the F content of groundwater used for drinking and cooking in eight villages of the Arsanjan area of Fars Province in the Iran. We also examined correlations between the F content of groundwater and other parameters such as pH, alkalinity, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, and total dissolved solids (TDS).

MATERIALS AND METHODS

The survey study was conducted between April and September in 2009 in the 1500-km^2 elevation Arsanjan area of Fars Province in southern Iran (Figure 1). The eight villages that were selected for study rely on local groundwater sources for drinking water with different levels of F. The selection of these villages was done in such way that all of them have essentially the same nutritional conditions and socio-economic standards.

The standard SPADNS method was used for analysis of F in the water (DR/5000s Spectrophotometer). Ca^{2+}, Mg^{2+} (both by the Calmagite Colorimetric Method), and NO_3^- (by the Cadmium Reduction Method) were also measured

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with the DR/5000 spectrophotometer (HACH Company, USA). Other parameters such as alkalinity (ALK), Cl^-, and total dissolved solids (TDS) were determined by standard methods,[11] and pH was determined using a pH meter.

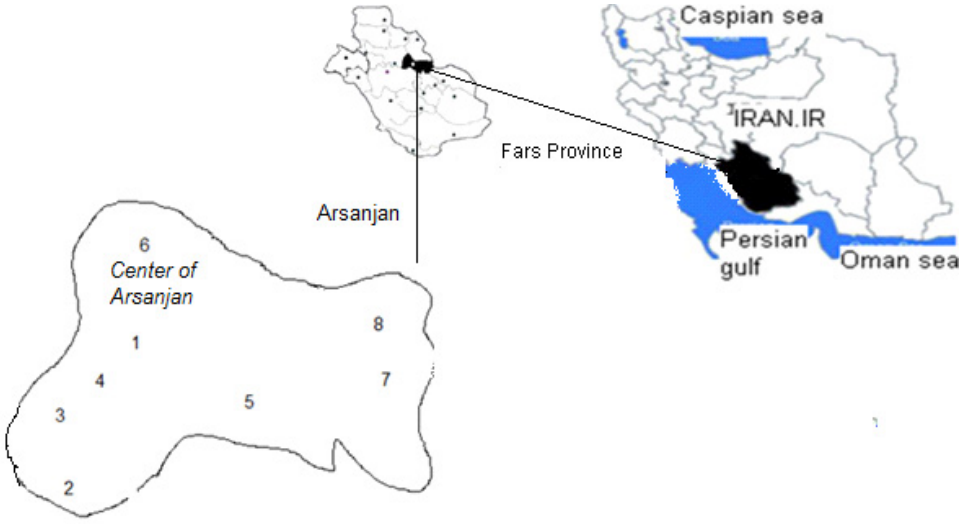

Figure 1. Location of the eight village sites in Arsanjan, Iran: (1) Salehabad, (2) Ghadamgah, (3) Dehbid, (4) Rahmatabad, (5) Chahrghalat, (6) Arsanjan, (7) Aslamabad, (8) Abasali.

Decayed permanent (D_t) and deciduous (d_t) teeth, not including filled or missing teeth, of the children in each village were determined according to the WHO standard[12] by two dentists using a sharp dental probe and examining each mouth under good natural light.

RESULTS AND DISCUSSION

The population and the number of children examined in each village are shown in Table 1, and the number of girls and boys and the total number of children in each of the three age groups are presented in Table 2.

Table 1. Arsanjan village populations and subject sample data

Village	Population	Children examined	Number of boys	Number of girls	Ratio girls/boys	Boys mean age	Girls mean age	Children mean age
Salehabad	1971	336	132	204	1.55	8.9	9.5	9.31
Ghadamgah	2351	512	276	236	0.86	9.3	9.1	9.23
Dehbid	1360	119	56	63	1.13	9.9	9.3	9.5
Rahmatabad	1752	266	141	125	0.87	9.4	9.5	9.46
Chahrghalat	1450	102	53	49	0.92	9.6	9.7	9.64
Arsanjan	15000	1004	526	478	0.91	9.8	9.6	9.7
Aslamabad	303	18	7	11	1.57	9.7	8.8	9.3
Abasali	253	19	10	9	0.90	9.1	9.7	9.4

Table 2. Number of girls and boys in each of the three age groups in the eight villages of the Arsanjan area

Village	Age 6 years		Age 9 years		Age 11 years	
	Girls	Boys	Girls	Boys	Girls	Boys
Salehabad	60	50	74	53	70	29
Ghadamgah	85	90	95	100	56	86
Dehbid	22	18	21	20	20	18
Rahmatabad	40	48	41	50	44	43
Chahrghalat	14	16	15	20	20	17
Arsanjan	161	170	159	169	158	187
Aslamabad	3	1	5	3	3	3
Abasali	2	3	4	3	3	4
Totals	387	396	414	418	374	387

As seen in Table 3, the content of F in the village groundwater was found to vary from 1.2 to 0.10 mg/L. There are many studies in Iran that have reported F level in drinking water and also in air at different concentrations.[13-17]

Table 3. Elevation, water F content, and dental caries in eight villages of the Arsanjan area

Village	Elevation (m) above sea level	Fluoride (mg/L)	Boys		Girls		Mean Dt	Mean dt
			D_t	d_t	D_t	d_t		
Salehabad	1660	1.20	0.29	1.65	0.23	1.69	0.29	2.11
Ghadamgah	1654	0.90	0.28	2.60	0.18	2.30	0.28	1.85
Dehbid	1690	0.80	0.10	1.10	0.15	1.23	0.12	1.10
Rahmatabad	1650	0.59	0.40	0.96	0.43	1.11	0.36	1.01
Chaharghalat	1696	0.41	0.31	2.33	0.32	2.13	0.28	3.30
Arsanjan	1700	0.40	0.24	1.23	0.19	1.12	0.31	1.20
Aslamabad	1705	0.11	0.33	2.65	0.36	2.40	0.33	1.98
Abasali	1720	0.10	0.21	2.33	0.20	2.10	0.21	2.89

In Table 3, with only small variations in elevation above sea level, overall D_t in the eight villages is seen to range between 0.12 and 0.36 and d_t between 1.01 and 3.3.

As seen in Figures 2 and 3 there was a slight downward, but not statistically significant trend between increasing F content of the drinking water and the mean D_t and d_t in each village.

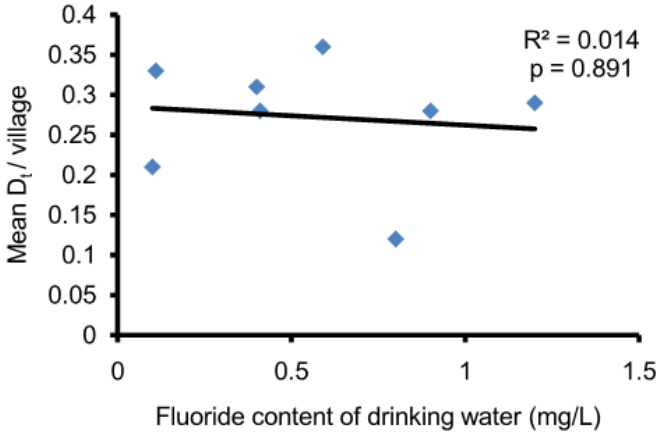

Figure 2. Relationship between the F content of the drinking water and the mean D_t in each village.

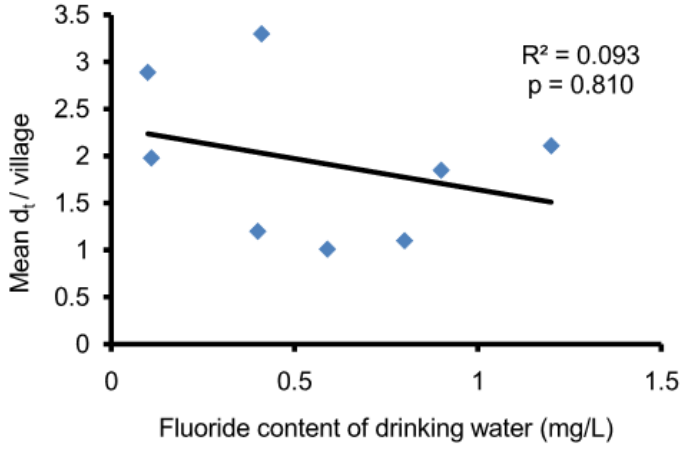

Figure 3. Relationship between the F content of the drinking water and the mean d_t in each village.

Table 4 records the breakdown of D_t and d_t for the three age groups. As in Table 3, linear regression analysis of the data in Table 4 indicated a weak trend toward less tooth decay with increasing F in the water. However, this trend was far from being statistically significant. The linear regression data for the F water level and the mean D_t and d_t in each age group are: 6-year age group D_t ($R^2 = 0.215$) and d_t ($R^2 = 0.172$), 9-year age group D_t ($R^2 = 0.247$) and d_t ($R^2 = 0.029$), and 11-year age group D_t ($R^2 = 0.001$) and d_t ($R^2 = 0.230$) (all $p > 0.20$ with the smallest $p = 0.298$ for D_t in the 9-year age group). Linear regression plots of the F content of the drinking water and the mean D_t in the 9-year and the 11-year age groups in Table 4 are shown in Figures 4 and 5.

Table 4. Increasing concentration of F in water and dental caries in three age groups in the Arsanjan area, Iran

Fluoride (mg/L)	Age 6 years (5.5–6.5)						Age 9 years (8.5–9.5)					
	Girls		Boys		Mean D_t	Mean d_t	Girls		Boys		Mean D_t	Mean d_t
	D_t	d_t	D_t	d_t			D_t	d_t	D_t	d_t		
1.2	0.21	1.72	0.20	2.10	0.20	1.91	0.18	1.61	0.21	1.96	0.19	1.81
0.90	0.27	1.91	0.19	1.79	0.23	1.81	0.25	1.81	0.18	1.79	0.23	1.80
0.80	0.12	1.11	0.13	1.20	0.13	1.15	0.15	1.35	0.10	1.29	0.12	1.32
0.59	0.35	1.00	0.37	0.99	0.36	0.99	0.30	1.90	0.29	1.51	0.29	1.71
0.41	0.29	2.91	0.28	3.21	0.28	3.15	0.19	1.01	0.14	1.02	0.16	1.01
0.40	0.30	3.10	0.26	2.29	0.28	3.01	0.19	3.19	0.19	2.98	0.19	3.01
0.11	0.33	2.00	0.35	1.89	0.34	1.95	0.39	2.01	0.37	1.96	0.38	1.99
0.10	0.19	2.37	0.22	2.51	0.21	2.46	0.25	1.39	0.25	1.41	0.25	1.40

Fluoride (mg/L)	Age 11 years (10.5–11.5)					
	Girls		Boys		Mean D_t	Mean d_t
	D_t	d_t	D_t	d_t		
1.2	0.22	1.99	0.21	2.01	0.21	2.00
0.9	0.31	2.10	0.34	1.91	0.33	2.01
0.8	0.28	1.21	0.30	1.11	0.29	1.16
0.59	0.40	1.31	0.35	1.31	0.36	1.31
0.41	0.32	3.00	0.30	2.99	0.31	3.00
0.4	0.29	2.98	0.30	3.20	0.29	3.11
0.11	0.33	2.32	0.29	2.50	0.31	2.40
0.1	0.21	2.41	0.20	2.40	0.20	2.40

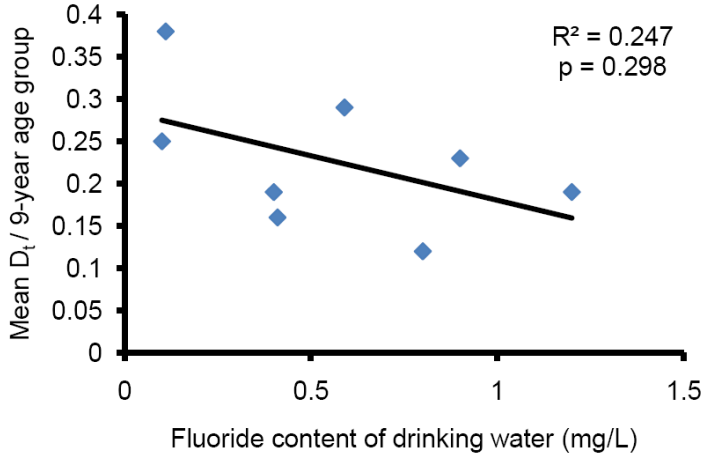

Figure 4. Relationships between the F content of the drinking water and the mean D_t in the 9-year age group.

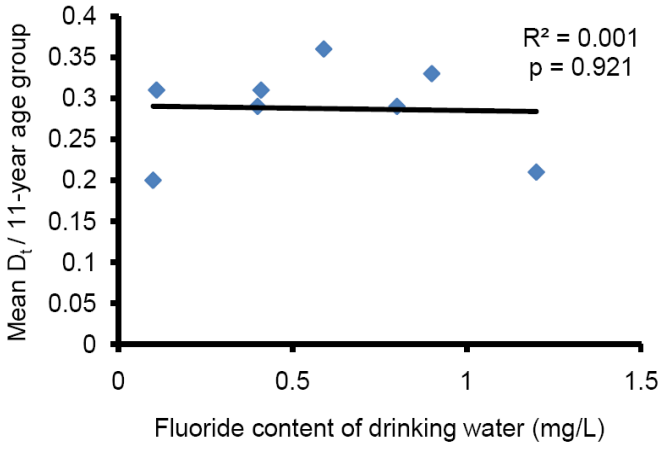

Figure 5. Relationships between the F content of the drinking water and the mean D_t in the 11-year age group.

As in a related study in Saudi Arabia that recorded no reduction in dental caries with water F above 1 mg/L,[8] an earlier study in Iran indicated that drinking water with 1.3 mg F/L had a negligible effect in preventing caries.[18] In a recent survey from another part of southern Iran, Dobaradaran et al. found that D_t and d_t in the 14 villages of the Dashtestan area of Bushehr Province showed no significant correlation with F content. When the village of Kuhn in that study with the highest water F and lowest caries scores but with the best access to primary and medical dental care was omitted, linear regression analysis of the remaining 13 villages actually showed a weak increase of D_t and d_t with increasing water F level.[6] As in our previous study with elevations of 90 to 1110 m above sea level,[6] there was also no correlation here between elevations of 1650 to 1720 m and D_t and d_t.

Correlation analyses between the F content and other inorganic constituents (Table 5) in this study also indicated there is no significant relationship between F content of the water with NO_3^-, ALK, Cl^-, SO_4^{2-} (Table 6). However, there was a significant and direct correlation between F with Ca^{2+}, Mg^{2+}, and TDS, in agreement with studies in Tamil Nadu, India,[19] and in Dashtestan, Iran.[11] There was also a significant inverse correlation of F with pH in our study. On the other hand, Gupta et al. in their study in the Birbhum district of West Bengal, India, found a weak inverse correlation of F with SO_4^-, Ca^{2+}, Mg^{2+}, and a weak direct correlation with Cl^- and pH.[20] Earlier, Karthikeyan et al. found both direct and inverse correlations of F with pH, Cl^- and SO_4^{2-} in Tamil Nadu areas of southern India.[21]

Table 5. Anionic and cationic characteristics of groundwater samples in eight villages of Arsanjan, Iran (F, SO_4^{2-}, Cl^-, Ca^{2+}, Mg^{2+}, TDS, and ALK are in mg/L). Maximum values are shown as bold italics; minimum values as bold underlined.

Village	F	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	TDS	ALK	NO_3^-	pH
Salehabad	***1.2***	**9**	30	***115***	41	611	**165**	7	**7.5**
Ghadamga	0.9	16	65	113	***42***	*615*	171	22	7.6
Dehbid	0.8	28	19	91	33	551	195	***23***	7.8
Rahmatabad	0.59	25	16	59.9	29.8	306	216	8	7.9
Chaharghalat	0.41	26	19	86	36	501	195	14	7.7
Arsanjan	0.4	***105.7***	***100***	101.4	27.4	542	196	21	***8.0***
Aslamabad	0.11	25	**10**	**42**	**20**	**250**	201	11	7.9
Abasali	**0.1**	95	18	80	35	412	***221***	**2**	***8***

Table 6. Correlation coefficients of water quality parameters in the eight villages of Arsanjan, Iran

Parameter	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	TDS	ALK	pH	NO_3^-
F	0.068	0.161	0.705*	0.686*	0.709*	–0.268	–0.820*	0.282
SO_4^{2-}		0.960†	0.542	0.129	0.479	0.410	0.154	0.538
Cl^-			–0.206	–0.323	–0.268	0.332	0.607	0.566
Ca^{2+}				0.803*	0.979**	0.358	–0.144	0.379
Mg^{2+}					0.772*	0.413	–0.410	0.026
TDS						0.250	–0.147	0.499
ALK							0.347	–0.405

*Correlation is significant at the 0.05 level. †Correlation is significant at the 0.01 level.

Finally, in view of the high concentration of F in drinking water in certain parts of Iran,[6,10,12] along with the extensive consumption of tea with a mostly modest F content,[22] the use of low-F bottled drinking water[16] and a hybrid sorbent resin for removal of F from such water[23] is recommended.

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