

Fluoride Content of Children's Teeth in One District in Japan with High Fluoride Content in Water

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The relationship between the fluoride content of water and teeth has been investigated by Armstrong and Brekhus(1938), McClure and Linkins(1951) and other authors from various points of view. However, there are very few reports about the relationship between the degree of mottling and teeth fluoride content. The fluoride content of children's teeth in Da Cunha, a region in The Netherlands with high fluoride in water was reported by Sognnaes and Armstrong (1941). There have also been the reports by Martin referring to Evanston in England(1948) and by Sakaetsuru about Takarazuka in Japan (1954), and by Tagashira et al.(1985).

We investigated the relationship between the degree of mottling and the fluoride content in mottled children's teeth in Takarazuka city where the down stream of Muko river is situated. That river originates in Rokko mountain which is composed of high fluoride content granite rocks(Tsurumaki and Sakuramoto 1962, Kusaka and Sagawa 1974, Muramoto et al.,1976, Tsuchiya et al. 1986).

The maximum fluorine concentration of river water in Muko river basin is 1.91 mg/L F and this value is very high compared with the average concentration of river waters in Japan (0.05 mg/L F). The fluoride content of mottled teeth strongly depended on the child's age which in most cases equalled the length of stay in Takarazuka city.

MATERIALS AND METHODS

Forty five teeth were collected from Takarazuka city, an area with high fluoride concentration in river water, well-water, rice plants and vegetables. The mottling had been carefully observed and classified by dentists for each child in the following degrees of severity : "very-mild" tiny white spots detectable only by a trained examiner(M₊); "mild" -opalescent or milky areas not difficult to detect but with little esthetical effect (M₁), "moderate"-stained areas inside but not on the enamel(M₂); "severe"-pits, grooves, or chalky areas on the enamel surface (M₃). The teeth were selected at random, cleaned, and dried at 80°C for 24 hours in a hot-air drier. Samples were ashed with the addition of CaO milk. Distillation with perchloric acid was carried out at 135-140°C and following standard methods(AOAC 1984). The obtained solutions were used for the determination of fluorine by colorimetric methods with Alfusson reagents(Dotite Reagents LTD), using a HITACHI spectrophotometer(wave length 620nm).

RESULTS AND DISCUSSION

Thirty-four sample teeth were divided by dentists into these groups: 11 teeth as M_{\pm} , 12 teeth as M_1 and 11 teeth as M_2 . The range of fluoride concentration of the 11 normal teeth (Table 1, Takarazuka) was from 78.9 to 189 $\mu\text{g/g}$ F. Figure 1 shows the relationship between the fluorine concentration of teeth and the age of children for the normal teeth, the ones that were not mottled but were affected by fluoride. Table 1 shows the relationship between the fluoride content of teeth and the age of children. The average fluoride concentration of children's teeth in Kurashiki City, an area with low fluoride content in water was 54.38 ± 7.51 $\mu\text{g/g}$, for 7 children of aged around 8 years old. If these teeth are taken as a control, then the Takarazuka children's teeth that were not mottled have an average fluorine concentrations more than two times the control. The fluorine concentration in normal teeth (including enamel and dentin of children) significantly increases with the age of the child ($p < 0.01$).

Table 2 shows the average fluorine concentrations of children's teeth for 3 groups in Takarazuka City plus one group in Kurashiki City (control). The fluorine concentration of male teeth was slightly higher than that of female teeth. No statistically significant dependence of the fluorine concentration in mottled teeth on age was found. However, significant difference was found between the average fluorine concentration of mottled teeth in both M_1 and M_2 groups. The concentration in these two groups was significantly higher than in M_{\pm} group. The average fluorine concentration of teeth was 131.8 ± 30.55 $\mu\text{g/g}$, 178.0 ± 45.13 $\mu\text{g/g}$, and 369.5 ± 132.7 $\mu\text{g/g}$ for M_{\pm} (normal), M_1 , and M_2 , respectively. By analysing the results for M_2 group, significant dependence of the fluorine concentration of teeth on age was recognized.

The histogram of distribution of the mottled teeth is shown in Figure 3. More than fifty percent of the mottled teeth were incisors. In general, the age of appearance of mottling in teeth is as follows: 6 - 7 years old for 1st molar teeth, 10 - 12 years old for incisors and 12 - 16 years old for 2nd molar teeth. The age of all the children in this investigation was from 5 to 12 except for two 13 year old girls. Takarazuka City is situated in a geologically distinctive area. The mountain area around Takarazuka is rich in granodiorite.

Table 1. Average fluorine contents of normal children teeth.

Sampling sites	Number of samples		F content (Mean \pm S.D) ppm
Takarazuka City	male	7	140.5 \pm 34.04
	female	4	
			116.7 \pm 26.79
Kurashiki City	male	4	54.38 \pm 7.51
	female	3	

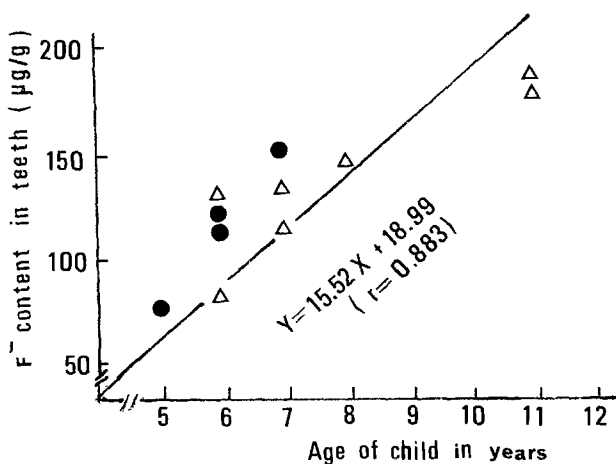


Figure 1. Relationship between the fluorine concentration of normal teeth and the age of children in a F-contaminated area.

△ : male, ● : female

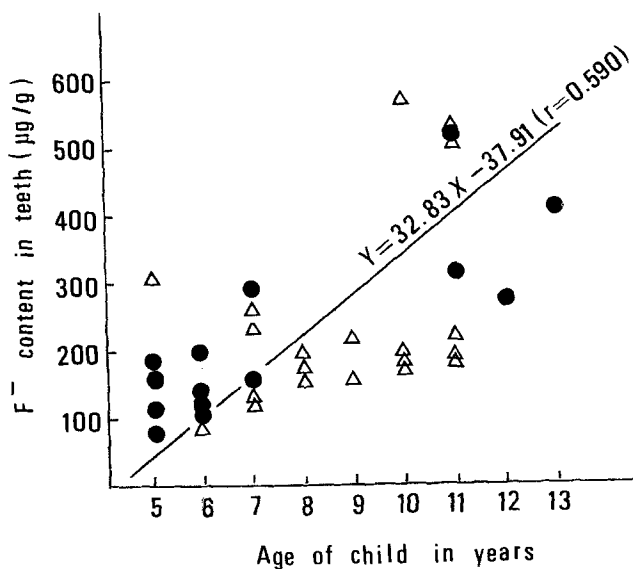


Figure 2. Relationship between the fluorine concentration of teeth (groups M₁ and M₂) and age of children.

△ : male, ● : female

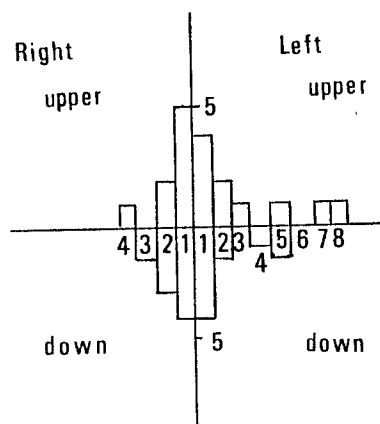


Figure 3. The histogram of dentition of the mottled teeth.

Table 2. Average fluorine concentration in teeth for various group.

Group *	F conc($\mu\text{g/g}$)	Average age of child	Number of sample	
M_2	369.5 ± 132.7	9.9	male 7) 11
			female 4	
M_1	178.0 ± 45.13	8.3	male 7) 12
			female 5	
M_{\pm}	131.8 ± 30.45	6.3	male 7) 11
			female 4	
Control**	54.38 ± 7.51	8.1	male 4) 7
			female 3	

*: The teeth were divided into three groups, according to the degree of mottling by dentists, Dr.Umemura and Dr.Ikuma, **: Sampling from Kurashiki City.

Figure 4 shows the sampling sites of river water in Muko River basin close to and inside Takarazuka City and Table 3 shows the average fluorine concentration of river waters, rice plants(brown rice, roots) and soil for three years .

The average fluorine concentration of the water of three rivers in Kurashiki City was 0.03 mg/L F. In contrast with this, the concentrations of Muko River basin ranged from 0.03 to 1.91 mg/L (the average fluorine concentration of 12 stations was 0.624 mg/L F), much higher than that of the control (Kurashiki City), and the average of 145 Japanese river waters (0.07 mg/L). The fluorine concentration of tap water ranged from 0.02 to 0.35 mg/L in Takarazuka City, while the average in Kurashiki City tap water is 0.02 mg/L F. However, the fluorine concentration of the formerly water-head water ranged from 2.05 to 2.53 mg/L F. These water were not used for drinking water around 30 years ago.

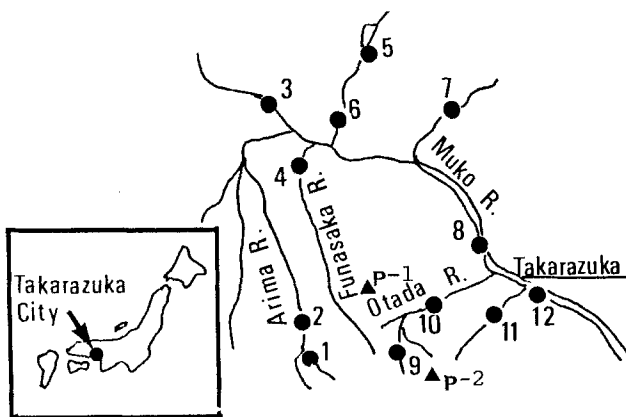


Figure 4. Sampling sites in Muko River and inflowing rivers around Takarazuka City.

Table 3. Average fluorine concentrations in river water, rice plants, and soil.

Station	pH	River water (mg/L)	Soil ^{a)} (μ g/g)	Rice plants ^{b)}	
				Brown rice	roots
1	7.4	0.56	136.5	9.87	32.9
2	7.7	0.80	141.1	10.6	49.8
3	6.8	0.07	59.9	3.19	15.7
4	7.4	0.52	79.8	4.49	11.9
5	7.3	0.03	70.1	4.12	13.5
6	7.3	0.15	68.7	3.20	13.5
7	7.3	0.03	71.3	2.97	14.6
8	7.5	0.13	106.4	4.96	26.6
9	6.9	1.91	150.5	15.2	31.6
10	7.6	1.60	135.8	11.69	69.23
11	7.2	1.47	280.7	10.43	69.20
12	7.3	0.35	130.1	9.82	67.7
Average	7.3	0.62	119.2	6.73	33.56
p-1	7.2	2.53	—	—	—
p-2	7.8	2.05	—	—	—

a), b): these values are presented in dry matter basis (μ g/g),
p-1: Momijidani formerly water head, p-2: Fukaya formerly
water head.

Also, the fluorine concentration of well- water ranged from 0.01 mg/L to 0.07 mg/L, and was higher than that of Kurashiki City. It was assumed that the mottled teeth were not especially affected by the fluoride of some plants, like rice and wheat because fluorides are generally characterized by poor accumulation in river water (irrigation water), rice plants and soil. It is considered that the fluoride content of teeth is highly dependent on the content of drinking water, which is affected by that of river water.

McClure (1951) reported a range of fluorine concentration in teeth, 86 - 97 μ g/g for enamel and 360 - 440 μ g/g for dentine tissue in the case of drinking water 0.1 mg/L F. Also, Brundevold (1966) reported that the fluoride content of teeth increased with increasing content of water.

Hodge(1950) reported that beginning at about 1 mg/L F, increasing the amount of fluorine in water produces a regular and linear increase in the severity of mottling, and below 1 mg/L F there was no indication that fluoride had any effect on the occurrence of the occasional spots or milky areas or hypoplasias that would be included in the observations of mottling. On the other hand, Dean(1946) reported that the number of caries in teeth decreased with increasing fluoride content in water.

The relationship between fluorine concentration in mottled teeth for various degrees of mottling and the age of children was examined. The average fluorine concentration of children teeth in each degree of mottling teeth was as follows: 128.6 $\mu\text{g/g}$ for M1(not mottled teeth); 178.9 $\mu\text{g/g}$ for M2(moderate stained) and 469.5 $\mu\text{g/g}$ for M3(Severe chalky). On the other hand, the average fluorine concentration in control was 53.8 $\mu\text{g/g}$ in a non-polluted area, Kurashiki City.

The fluoride content in mottled teeth had a tendency to increase with the age of child. Therefore, it was considered that the fluoride content in teeth was affected by the length of exposure to high fluoride levels. The average fluorine concentration of rivers in Takarazuka region is much higher than the average fluorine concentration in Japanese rivers due to the presence of granodiorite and granite.

It would be advisable to maintain the tap water in Takarazuka district below 0.03 mg/L. So it is necessary to continue watching the fluorine concentration of river water and tap water. More than 30% of the water samples in Muko River basin had a F concentration higher than 0.8 mg/L F. It is considered that the children teeth were affected mainly by the high fluorine concentration in tap water and also perhaps by high fluoride content of vegetables which came as a result of the high fluorine concentration in river water.

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