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Concentrations of Fluoride in Drinking Water and Tea Samples and Associations with Dental Fluorosis

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Abstract: Water and tea are the main sources of fluoride intake in humans and may cause dental fluorosis during tooth development. The current study aimed to determine the fluoride concentrations in drinking water and tea samples and their association with dental fluorosis. To evaluate the prevalence of dental fluorosis, 882 primary school children (8-13 years) were analyzed and 14% were found to be affected. Drinking water samples (34) were analyzed and the fluoride concentrations ranged from 0.61 to 2.55 ppm. Fourteen (14) different branded and unbranded tea leaf samples exhibited fluoride concentrations of 5.73-7.70 and 2.13-4.56 ppm, respectively, based on the ion-selective electrode method. It was concluded that the dental fluorosis observed among school children was directly associated with the fluoride concentrations in their drinking water and tea samples.

Key words: Fluoride intake, water, tea, dental fluorosis

INTRODUCTION

Epidemiologically, water is considered to be the most important source of fluoride (75-90%). Fluoride concentrations vary in different water sources, such as seawater (1.2-1.4 mg/L) and ground water (0.2-67 mg/L), the latter which is a main source of human intake (Tokalioglu *et al*., 2004; Dozol *et al*., 2005). There are elevated fluoride concentrations in the water in many countries including Pakistan. In Pakistan, the areas associated with high fluoride exposure risks are Lahore (0.05-19.70 ppm) and Quetta (0.03-24.4 ppm) (Shah and Danishwar, 2003; Tahir and Rasheed, 2013). In addition to water, tea is a major source of fluoride intake because tea plants absorb high levels of fluoride from the air and soil and 98% is this fluoride accumulates in the leaves that are used in beverages, e.g., green and black tea (Cao *et al*., 2000). In humans, after conversion into hydrogen fluoride, the stomach absorbs almost 40% of the consumed fluoride (Mansfield, 2010). The remaining fluoride is absorbed by the small intestine and the blood then circulates it throughout body where it is subsequently stored in calcium-rich body parts, such as the teeth and bones (Whitford, 1989). Fluoride was artificially introduced into toothpastes because at normal concentrations, it prevents tooth decay; thus, toothpastes are an additional source of fluoride intake (Tahir and Rasheed, 2013). Excessive fluoride intake causes adverse effects, such as hypothyroidism, gastric discomfort and low IQ (NRC, 2006; Klein *et al*., 2001; Haddow *et al*., 1999; Gupta *et al*., 1992). Fluoride causes skeletal fluorosis via the abnormal activation of osteoclasts (Li, 2003; Fawell *et al*., 2006). Dental fluorosis is another adverse effect of exposure to high levels of fluoride during tooth development. Dental fluorosis changes the structure and composition of the enamel, which in the mild stage results in a diffused white striated opaque appearance (DenBesten and Thariani, 1992). Improper mineralization due to high concentrations of fluoride produces porous enamel and the exposure of this porous enamel to exogenous ions, such as iron and copper, causes discolouration (Yoder *et al*., 1998; Thylstrup and Fejerskov, 1978). The clinical severity of dental fluorosis depends on the exposure and the source of fluoride. Age, nutrition and renal insufficiency are also important factors (Akpata *et al*., 1997). Dental fluorosis is classified as mild, moderate or severe, occurs during tooth development and children aged 1-4 are at high risk (Thylstrup and Fejerskov, 1978). The current study sought to the correlate fluoride concentrations in water and tea with dental fluorosis in three districts of Balochistan.

MATERIALS AND METHODS

The design of this study was approved by the ethical review committee of the institute. 882 school children were analyzed for dental fluorosis. To estimate the fluoride concentrations of the children with dental fluorosis, 34 drinking water samples (from tube wells, wells and taps) were collected from nearby vicinities of the students' residences (Quetta, Mastung and Loralai districts) in 100-ml sterile polyethylene bottles. Almost 14 tea leaf samples (branded and unbranded) were taken from local markets and filtered tea infusions were prepared by boiling. The fluoride concentrations of 25

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mg tea samples were analyzed in water and tea liquor with a calibrated ion metre (Jenway 3345, Germany) in triplicate (Tahir and Rasheed, 2013; NRC, 2006). Socioeconomic factors, including oral health, brushing and tea and rice consumption, were also investigated via a questionnaire. A dentist used the World Health Organization's (WHO, 1994) Dean's index to determine the clinical severities dental fluorosis (Fawell *et al*., 2006).

RESULTS AND DISCUSSION

The prevalences and severities of dental fluorosis were investigated in Quetta, Mastung and Loralai. A total of 822 individuals aged 6-15 years were examined for dental fluorosis and 15% (123) were found to be affected with different clinical severities (Table 1, Fig. 1). In Quetta, Mastung and Loralai, 13, 40 and 15% of the children, respectively, were found to have dental fluorosis and these prevalences were lower than that reported in a comparable study conducted in the GADAP town of Karachi, where 53.33% (315) of the children were found to be affected (Abid *et al*., 2014). Another study conducted in Lahore also concluded that the concentration of fluoride in the drinking water was associated with dental fluorosis (Sadia and Rizwan, 2013). A cross-sectional study was conducted among 349 12-year-old school children in Quetta, Pakistan and found a high prevalence of dental fluorosis of 63.6% with 32.1 and 27.5% of the children exhibiting moderate and mild severities, respectively, according to the Dean's Index (Erum *et al*., 2015).

Among the 34 drinking water samples, the fluoride concentrations ranges were 0.61-2.55 ppm, 1.14-1.72 ppm and 0.64-1.36 ppm in the Quetta, Mastung and Loralai districts, respectively (Table 2). The fluoride concentrations were 0.61-1.66 ppm (mean 1.19 ppm and SD 0.29 ppm) in the tube well water, 0.64-1.69 ppm (Table 3) in the well water and 0.89-2.55 ppm (Table 3) in the tap water. These findings are comparable with those of a study conducted in different areas of Punjab that reported an average value of 2.53 ppm and a range of 0.5-5.01 ppm (Qayyum *et al*., 2013). Tahir and Rasheed (2013) determined the fluoride concentrations in the drinking water of different areas of Pakistan. These authors concluded that 16% of the monitored water sources had fluoride concentrations that exceeded the permissible safe limit of 1.5 ppm and the concentration range of these sources was 1.6-25 ppm (Tahir and Rasheed, 2013).

The World Health Organization's permissible limit for fluoride in the water is 1.5 ppm (Fawell *et al*., 2006) and all three of the investigated districts in the current study exhibited variable fluoride concentrations between the peak value of 2.55 ppm and the lowest value of 0.61 ppm, which was observed in Quetta. These findings indicate that high concentrations of fluoride may have been responsible for the dental fluorosis observed among the individuals in the current study.

The consumption of tea and the fluoride concentrations in the different branded and unbranded tea samples were analyzed (Table 4). The fluoride concentrations ranged from 5.73-7.70 ppm in the branded teas and 2.13-4.56 ppm in the unbranded teas. A similar study was performed in Croatia to determine the fluoride contents of tea infusions. The average fluoride concentration among all of the tested samples was 0.116±0.211 ppm, which is below the concentration observed in the current study (Josipa *et al*., 2012). Another study performed in Indonesia revealed fluoride concentrations that ranged from 0.95 to 4.73 ppm for black tea infusions, 0.70 to 1.00 ppm for green teas

Table 1: Prevalence and severity of dental fluorosis in different areas of Baluchistan

		Dental fluorosis				
Sampling area	No. of individuals surveyed	Mild	Moderate	Severe	Total	Percentage
Quetta	300	05	08	26	39	13
Mastung	22	03	04	02	09	40.9
Loralai	500	09	17	49	75	15
Total	822	17	29	77	123	14.97

Table 2: Fluoride concentration in drinking water of three targeted areas of Baluchistan province

Sampling area	No. of water samples	Range of fluoride conc. (ppm)	Mean fluoride (ppm)	±SD
Quetta	9	0.61-2.55	1.54	0.52
Mastung	7	1.14-1.72	1.35	0.23
Loralai	18	0.64-1.36	0.98	0.15
Overall	34			

Table 3: Mean fluoride concentration (ppm) in three main water sources of Baluchistan

Sources of water	No. of water samples	Range of fluoride conc. (ppm)	Mean fluoride (ppm)	±SD
Tube well	20	0.61-1.66	1.19	0.29
Well	7	0.64-1.69	1.14	0.41
Tap water	7	0.89-2.55	1.54	0.55
Overall	34			

Table 4: Fluoride concentration in branded and unbranded tea samples

Branded tea			Unbranded tea		
Tea samples	F concentration	pH	Tea samples	F concentration	pH
Fluoride concentration in tea samples					
BT1	6.15	6.641	UT 1	3.18	4.482
BT2	5.73	5.413	UT 2	3.93	5.213
BT3	6.41	5.517	UT 3	3.63	5.356
BT4	7.70	6.318	UT 4	4.52	6.165
BT5	7.53	5.325	UT 5	2.59	5.324
BT6	7.21	6.714	UT 6	2.39	5.120
			UT 7	2.13	6.681
			UT 8	4.56	5.445

Fig. 1: Dental fluorosis in an individual

infusions and 0.26 to 0.27 ppm for herbal tea infusions (Yuwono, 2005). An investigation of the fluoride contents of different commercial brands of black tea in Iran revealed a range of 0.53 to 2.60 ppm (Mahvi *et al*., 2006). The current study provides evidence that the concentrations of fluoride in drinking water and tea leaves are above the permissible limit, which affects human health and may lead to fluorosis. Therefore, preventive measures, such as water purification, quality testing and regular dental check-ups, are recommended to identify and control elevated fluoride concentrations.

Conflicts of interest: All authors declare that they have no conflicts of interest.

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