Original Article

Estimation of Fluoride Content of Drinking Water in Dharan

Bandana Koirala[1], Surya Raj Niraula[2], Anup Ghimire[3]
[1]Department of Pedodontics and Preventive Dentistry, [2]School of Public Health and Community Medicine, [3]School of Public Health and Community Medicine;
BP Koirala Institute of Health Sciences, Dharan, Nepal

Abstract

Introduction: Fluoride when present in drinking water at optimal level has been shown to promote oral health by preventing tooth decay. Dental caries represents a health problem that impacts on the medical, functional, nutritional and psychological status of patients in all the age groups. Fluoridation of public water supply is a safe, economical and effective measure to prevent dental caries.

Objective: To estimate the level of fluoride present in drinking water supplies in all the wards of Dharan and to compare the fluoride concentration of its different water supply sources.

Methods: One hundred water samples were collected from the various sources (ground water and surface water) and its different reservoirs along with random samples of 2-7 from all the wards of Dharan. The samples were then taken to the SEAM-N-MMA laboratory, Biratnagar to be tested for fluoride using the photometric method. Microsoft excel for data entry and SPSS 11.5 version for analysis were used. Significance of the variables was examined by Chi-square test.

Results: The results of this study showed that in 96% of the samples taken, fluoride level was below the optimal. Only few samples met the lower range guideline value of Nepal (0.5 mg/l). Also, there was significant difference ($p< 0.002$) between the surface and consumer level fluoride.

Conclusion: The fluoride content in drinking water supplies of Dharan was found to be below optimal level as per the national and WHO guideline values.

Key Words: Dental caries, drinking water, fluoride

Introduction

Fluoride is one of the most plentiful elements on earth and occurs naturally in water supplies in varying amounts. When fluoride is present in drinking water at optimal levels, it has been shown to promote oral health by preventing tooth decay. Water systems are considered naturally fluoridated when the natural level of fluoride is greater than 0.7 parts per million (ppm). When a water system adjusts the level of fluoride to 0.7-1.2 ppm, it is referred to as water fluoridation.

Address for correspondence
Dr. Bandana Koirala, Professor and Head
Department of Pedodontics & Preventive Dentistry
BP Koirala Institute of Health Sciences, Dharan
Email: drbkbandu@yahoo.com

In the 1940s, scientists discovered that people who lived where drinking water supplies had naturally occurring fluoride levels of approximately 1 part fluoride per million parts water or greater (> 1.0 ppm) had fewer dental caries than people who lived where fluoride levels in drinking water were lower.[1,2] Numerous reports documenting reduced dental caries prevalence after exposure to fluoridated water supplies have appeared in a variety of sources.[3] These studies comparing fluoridated and non-fluoridated communities have reported decrease in the overall prevalence of dental caries, and for summary scores of dental decay identified as the "DMF" for permanent teeth and the "def" for primary teeth. These summary

scores represent the cumulative caries experience based on the number of decayed (D or d), missing or extracted due to caries (M or e) or filled (F or f) tooth surfaces. Additional studies have documented increased caries prevalence following withdrawal of fluoride supplementation of drinking water.[4,5] Frequent exposure to small amounts of fluoride each day will best reduce the risk for dental caries in all the age groups, hence, it is recommended that all persons drink water with an optimal fluoride concentration and brush their teeth twice daily with fluoridated toothpaste.[6]

The action of fluoride on teeth involves both topical and systemic mechanisms. Fluoride acts to stabilize the hydroxyapatite matrix on internal and external tooth surfaces.[7,8] Topical application of fluoride has been shown to decrease levels of dental plaque bacteria.[9] Systemic fluoride is provided by fluoridated public water supplies, dietary supplements, food and beverages. Sources of topical fluorides include fluoride-containing dentifrices, mouth rinses and gels. When used appropriately, fluoride is both safe and effective in preventing and controlling dental caries. Though it is proved that appropriate amount of fluoride consumption helps in combating dental caries, number of adverse effects have been seen with chronic ingestion of high doses on human health of which dental fluorosis is the commonest.[10] The American Academy of Pediatrics (AAP) has issued a schedule for fluoride supplementation.[11] These recommendations take account of the levels of fluoride contained in the primary drinking water supply as well as the age of the pediatric patient. Changes in the current AAP schedule include the elimination of fluoride supplementation during the first six months, decreased doses of supplemental fluoride from age six months to six years, and decreasing the level at which no supplementation is needed from 0.6 ppm to 0.7 ppm. When drinking water levels of fluoride are suboptimal, dietary supplementation should be considered for preventing dental caries which is supported by the U.S. Preventive Services Task Force.[12] The prevalence of dental caries is 42% at five years of age, increasing to more than 84% by age 17.[13-15] The Health Care Financing Administration estimates that 5% of the total health care expenditures (or $34 billion) is spent on dental services of which 13.2% (or $4.5 billion) is used for amalgam restorations.[16]

Dental caries represents a health problem that impacts on the medical, functional, nutritional, and psychological status of patients in all the age groups. Fluoridation of public water supply is a safe, economical and effective measure to prevent dental caries. The Centers for Disease Control and Prevention (CDC) considered the reduction in tooth decay from fluoridation as one of the top public health achievements of the 20th Century.[2] Very limited studies with minimal coverage have been conducted in Nepal.[17,18] Therefore, the present study aimed to estimate the level of fluoride present in drinking water supplies in all the wards of Dharan and to compare the fluoride concentration of its different water supply sources.

Materials and Methods

The study was conducted in Dharan municipality- a city of Eastern Nepal. Dharan is located on the foothills of Himalayas in the eastern region in the Sunsari District. Surface water being the major source of water in Dharan, the ground water source meets the dry season demand through its five differently located wells. 100 water samples were collected

from the various sources i.e., ground water and surface water and its different reservoirs along with random samples of 2-7 from different wards of Dharan.

The coding list was prepared. Water samples were collected in sterilized plastic bottles provided by the SEAM-N-MMA laboratory and according to the sample collection protocol by the same investigator and the collected samples stored in the icebox immediately. The samples were then taken to the SEAM-N-MMA laboratory, Biratnagar to be tested (using the photometric method which allows a reliable determination of fluoride) on the same or the next day. All the samples were stored in the refrigerator if not taken to lab the same day.

Data Management and Analysis:

The corrected data was entered into the computer through Microsoft excel software and checked in every fifth entry and corrected if any false entry was seen. After purifying the data, it was converted into SPSS 11.5 version software and analysis was done.

Frequency and percentage were presented to describe the nature and the characteristics of the variables. Corrected Chi-square test was used to assess the significant difference in between different sources. The probability of rejection of null hypothesis was set at 'p' value less than 5%.

Results

Fluoride content in source and consumer level was below optimal and was found to be significantly different. Table 1 and Table 2 represent the analyzed report.

Table 1: Fluoride content of drinking water taken from source and consumer levels

Levels	Fluoride Concentration (mg/l)			Total
	< 0.05	0.05- 0.49	>= 0.50	
Source	11	11	2	24
	45.8%	45.8%	8.4%	100.0%
Consumer	10	64	2	76
	13.2%	84.2%	2.6%	100.0%
Total	21	75	4	100
	21.0%	75.0%	4.0%	100.0%

(Chi square = 12.46, df= 1, p< 0.002)

In all the samples taken from the ground level, fluoride content was seen to be below optimal. Out of the 16 samples taken from the surface sources, 12.5% of the samples were found to have optimal level of fluoride in the range of 0.55- 0.67 mg/l. At the consumer level, only 2.6% were within the lower optimal level (0.52 mg/l). The concentration of fluoride in the remaining samples is described as follows: 20% of the samples had fluoride level below 0.05mg/l. Similarly, 7% of the total samples taken had fluoride level within 0.05- 0.09 mg/l. Of the remaining samples, 30%, 23%, and 15% had fluoride levels of 0.1 mg/l, 0.2 mg/l, and 0.3 mg/l, respectively. Only one sample had 0.4 mg/l of fluoride.

Since there is zero cell frequency in case of ground source, we have only included surface level and consumer level for the significance test. This test shows there was significant difference between the surface and consumer levels of fluoride (Chi-square= 12.46, df= 1, p< 0.002). Table 2 below represents the number

and distribution of samples amongst all the wards of Dharan.

Table 2: Fluoride content of drinking water from various sources and individual wards

Source/Ward	Fluoride Concentration (mg/l)			No. of Samples
	< 0.05	**0.05- 0.49**	**>= 0.5**	
Surface Source	7	7	2	16
	43.8%	43.8%	12.5%	100.0%
Ground Source	4	4	0	8
	50.0%	50.0%	.0%	100.0%
Wards				
1	0	3	0	3
	.0%	100.0%	.0%	100.0%
2	0	2	0	2
	.0%	100.0%	.0%	100.0%
3	3	2	0	5
	60.0%	40.0%	.0%	100.0%
4	0	3	0	3
	.0%	100.0%	.0%	100.0%
5	0	1	1	2
	.0%	50.0%	50.0%	100.0%
6	4	0	0	4
	100.0%	.0%	.0%	100.0%
7	0	6	0	6
	.0%	100.0%	.0%	100.0%
8	1	5	0	6
	16.7%	83.3%	.0%	100.0%
9	0	1	1	2
	.0%	50.0%	50.0%	100.0%
10	0	2	0	2
	.0%	100.0%	.0%	100.0%
11	0	4	0	4
	.0%	100.0%	.0%	100.0%
12	0	4	0	4
	.0%	100.0%	.0%	100.0%
13	0	2	0	2
	.0%	100.0%	.0%	100.0%
14	0	1	0	1
	.0%	100.0%	.0%	100.0%
15	2	3	0	5
	40.0%	60.0%	.0%	100.0%
16	0	7	0	7
	.0%	100.0%	.0%	100.0%
17	0	3	0	3
	.0%	100.0%	.0%	100.0%
18	0	12	0	12
	.0%	100.0%	.0%	100.0%
19	0	3	0	3
	.0%	100.0%	.0%	100.0%
Total	21	75	4	100
	21.0%	75.0%	4.0%	100.0%

Discussion

The relationship between environmental fluoride and human health has been studied for over 100 years by researchers from a wide variety of disciplines. Fluoride's ability to inhibit or even reverse the initiation and progression of dental caries is well documented. The first use of adjusted fluoride in water for caries control began in 1945 and 1946 in the United States and Canada, when the fluoride concentration was adjusted in the drinking water supply of four communities after scientists discovered that higher natural levels of fluoride in a community water supply were associated with fewer dental caries amongst the residents.[19-22]

Fluoride at optimal level in drinking water reduces the incidence of dental caries and slows or reverses the progression of existing lesions (prevents cavities). Dental caries is an infectious, multifactorial disease afflicting mostly the industrialized countries and some developing countries. Widespread use of fluoride has been a major factor in the overall decline in recent decades in the prevalence and severity of dental caries all over the world. However, exposure to higher levels of fluoride may harm our health. The health effects depend on the type of fluoride we are exposed to, duration of exposure, and how much it gets into our body. So, the present study analyzed the level of fluoride present in drinking water supplies in all the wards of Dharan and compared the fluoride concentration of different water supply sources in Dharan municipality.

The results of this study showed that in 96% of the samples taken, fluoride level was below optimal. Only 4% of the samples taken met the therapeutic level, that too in the lower limit. In a study done by Neil McDonald on Nepal's drinking water fluoride profile[23] (Dharan's water sample was not included), 95% of the samples had fluoride levels below 0.3 mg/l and more than 70% of sites registered less than 0.1 mg/l whereas in our study, 80% of the samples had fluoride levels below 0.3 mg/l and 30% below 0.1 mg/l.

However, we were not able to estimate the mean value of fluoride content in the drinking water of Dharan as the laboratory test report of SEAM-N-MMA did not report the exact value for those samples whose fluoride measurement values were less than 0.05 mg/L. This is a limitation of our study. However, the level of fluoride has been explored in terms of categories in the result.

For the prevention of dental decay, the Public Health Service (PHS) has since 1962 recommended that public water supplies contain fluoride at concentrations between 0.7 and 1.2 mg/l. PHS scientists representing the National Institutes of Health, CDC, the Food and Drug Administration, the Agency for Toxic Substances and Disease Registry, and other government agencies conducted an extensive examination of the worldwide biomedical literature on the public health risks and benefits of fluoride in 1991 and completed a report on the risks and benefits of exposure to fluoride in drinking water. The PHS report from 50 years of experience determined that adding fluoride to drinking water supplies has reduced tooth decay in all the age groups. The PHS also noted that there are health and economic benefits of water fluoridation for people of all ages and social and economic groups, especially for children who do not get adequate dental care. In 2000, the PHS published the first ever Surgeon General's

Report on Oral Health in America.[24] The report emphasizes that community water fluoridation is an effective, safe, and ideal public health measure benefiting individuals of all the ages and socioeconomic strata by substantially reducing tooth decay. Similarly, CDC's 2013 recommendation of community water fluoridation states fluoride "as being safe, effective, and inexpensive way to prevent tooth decay among populations living in areas with adequate community water supply systems, and that fluoride should be taken in the proper amount similar to many vitamins and minerals we consume for our health."[25]

According to the government of Nepal issued implementation directives for National Drinking Water Quality Standards, the fluoride guideline value (G.V.) stands as: 0.5- 1.5 mg/l. However, our results showed the fluoride level to be below optimal in most of the samples. Fluoride content of different water sources being at the lower range of national and WHO G.V. has helped us to understand the vulnerability of children's teeth to caries in Dharan. Since the fluoride level in our locality was found deficient, fluoridation of water supply of the entire Dharan municipality is deemed mandatory. Dharan's drinking water supply is met through ground water round the year except during the monsoons where the water supply is met largely from surface source. This can be utilized as an advantage to fluoridate the source water accordingly. The finding of our research also suggests use of fluoridated toothpastes wherever water fluoridation is not possible.[19,26] But with the present controversies of fluoride[27-29] along with the unavailability of affordable fluoridated toothpastes, this issue needs a larger body meet discussions representing all the stakeholders for seeing both the pros and cons of fluoridation and acting thereof for the benefit of the entire community.

Conclusion

The findings of this study showed that in 96% of the samples analyzed, fluoride level was found to be below optimal. Out of the 16 samples from the surface sources, only 12.5% met the lower range guideline value of Nepal (0.55- 0.67 mg/l), whereas, at the consumer level, only 2.6% of the samples were within the lower optimal limit, and this difference was statistically significant ($p< 0.002$).

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