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Fluoride Level in Drinking Water Sources of Eastern Nepal

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ABSTRACT

Background: Water is essential for the survival of every living organism of this planet, we humans being no exception to this fact. In context of oral health promotion, fluoride when consumed in recommended level decreases the solubility of enamel to acidic exposure and improves the strength of dental enamel that eventually helps reduce dental caries.So, this study was conducted to estimate the fluoride concentration in drinking water of eastern development region Nepal.

Methods: Water samples (165) were randomly collected from drinking water sources of Eastern Development Region, Nepal. Three categories of water samples (municipal, natural, packaged bottle water) each from three most populated cities of every district in the region were collected. The water samples were collected in autoclaved polypropylene plastic vessels. American Public Health Association 4500 F^- D method was used for fluoride estimation.

Results: Majority of the water samples (88.2%) had fluoride concentration below the optimum as per WHO guideline. Median fluoride concentration of municipal water supply, natural water resources and packaged bottle water was 0.09 ppm (<0.05 to 1.11 ppm), 0.13 ppm (<0.05 to 1.80 ppm) and 0.05ppm (<0.05 ppm to 0.78 ppm) respectively. Median fluoride concentration of Himalayan region, hill region and terai region was 0.17 ppm, 0.10 ppm and 0.07 ppm respectively. Overall median fluoride concentration of eastern development region Nepal was 0.08 ppm (<0.05 pmm to 1.80 ppm).

Conclusions: This study illustrated that fluoride concentration of most of the drinking water resources of eastern Nepal was below the recommended optimum level as per WHO guidelines.

Keywords: Drinking water sources; eastern Nepal; fluoride concentration.

INTRODUCTION

Optimal fluoride (0.5 - 1.5 mg/L) in drinking water is beneficial for the growth and development of human skeleton.[1] Fluoridated water when consumed in recommended level decreases the solubility of enamel to acidic exposure and improves the strength of dental enamel that eventually helps reduce dental caries. Fluoride delivery via water fluoridation is the most cost effective and efficient mechanism at large community scale.[2]

In Nepal, caries prevalence is 64% in urban area and 78% in rural population.[3] Comparison of world wide data over the last 20 years shows an increasing trend of untreated dental caries.[3] The community water fluoridation can be a milestone in reducing the burden of dental caries in developing countries like Nepal. Human populations are exposed to varying level of fluoride concentration based on the geographical distribution of drinking water sources.[4] Hence, the study aims to determine the fluoride concentration in drinking water sources of eastern development region of Nepal.

METHODS

It was a cross sectional study conducted in Eastern Development Region, Nepal from June 2017 to December 2017. Ethical approval for the study was obtained from the Institutional Review Committee, BPKIHS, Dharan (Ref. No.: IRC/0908/016).

Samples were randomly collected from drinking water sources of Eastern Development Region, Nepal. The most populated areas were taken into consideration for collection of sample as the fluoride status of the drinking water has positive/ negative effect on dentition status of the people consuming the same water for drinking purpose. The water samples were collected in autoclaved

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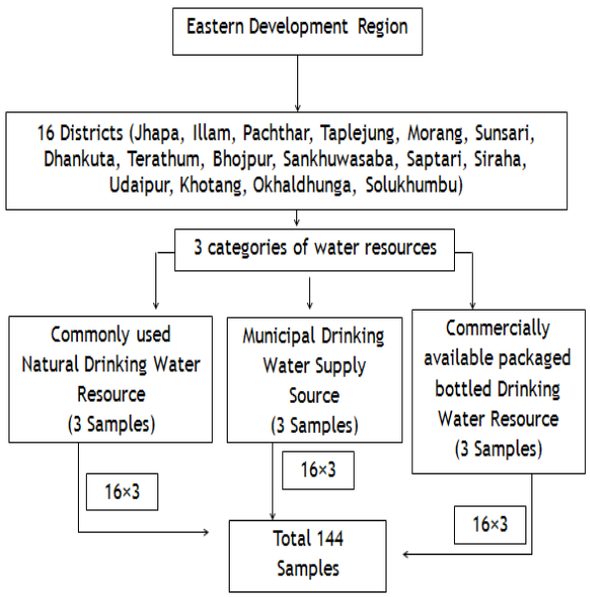
polypropylene plastic vessels. Water commonly used for drinking purpose from municipal supply, natural resources like rivers, springs, tube well, hand pumps etc., and packaged bottle water were included in the study. Inaccessible drinking water sources and the sources contaminated with human excreta and industrial byproducts were excluded.

Sample size was calculated as 142 based on the mean fluoride concentration from research by Manipal *et al.*[2] Considering the chances of damage to the samples during transport and to check for the reliability 165 samples were included in the study. Three categories of water samples (municipal, natural, packaged bottle water) each from three most populated cities of every district (16) in the region were collected. A total 144 samples, thus collected, were considered for comparative analysis.



The samples were stored at room temperature and were dispatched as early as possible to the ISO certified laboratory, Nepal Batawaraniya Sewa Kendra, Biratnagar, Morang, Nepal for estimation of fluoride concentration not exceeding 15 days from the day of sample collection.

The laboratory investigator was blinded regarding the area from which the samples were collected. Each sample was pre-coded by the principal investigator before the sample was dispatched to laboratory for analysis. Laboratory procedures were calibrated by retesting 10% of the water samples before further analysis.

APHA Method 4500 F^- D (SPANDS colorimetric method based on the reaction between fluoride and a zirconium dye lake) i.e. Standard Methods for the Examination of Water and Waste water; standardized and approved by American Public Health Association was used to estimate fluoride.

After completion of the sample collection and fluoride level estimation, data obtained were entered in Microsoft Excel Sheet 2007 and statistical analysis was done in Statistical Package for Social Sciences (SPSS version 11.5). Mean, median, range and standard deviations were computed for fluoride concentration. Frequency distribution (percentage) of different category and resources of water samples were calculated and appropriate graphs and tables were made.The mean difference between different categories of the water sources were assessed using Kruskal-Wallis test.

RESULTS

Majority of the water samples (88.2%) had below the optimal fluoride concentrationsas per WHO guideline.[1] Fluoride concentration was below detectable range (<0.05 ppm) in 51 samples (35.4%). The samples with fluoride concentration more than 0.10 ppm are shown in table 1. Fluoride mapping has been illustrated in figure 2. Median fluoride concentration of municipal water supply, natural water resources and packaged bottle water was 0.09 ppm (<0.05 to 1.11 ppm), 0.13 ppm (<0.05 to 1.80 ppm) and 0.05ppm (<0.05 ppm to 0.78 ppm) respectively. Median fluoride concentration of Himalayan region, hill region and terai region was 0.17 ppm (<0.05 to 0.64 ppm), 0.10 ppm (<0.05 to 1.05 ppm) and 0.07 ppm(<0.05 to 1.80 ppm) respectively (table 2). Overall median fluoride concentration of eastern development region Nepal was 0.08 ppm (<0.05 pmm to 1.80 ppm). The comparison of fluoride concentration among different water resources showed statistically significant difference (p=0.015) but there was no statistically significant difference in fluoride concentration of different regions (p=0.161). (Table 3)

Table 1. Places with fluoride concentration ≥ 0.10 mg/L (ppm).

District	Place (Category)	Fluoride Concentration in mg/L (ppm)
Morang	Biratnagar (M); Kanchanbari (N); Belbari (N)	0.12; 0.25; 0.31
Jhapa	Damak (P)	0.48
Saptari	Rajbiraj (N); Rajbiraj (M)	0.18; 0.13
Sunsari	Inaruwa (N)	0.10

Udaypur	Gaighat (N); Gaighat (P)	0.39; 0.10
Udaypur	Katari (M); Katari (N)	0.91; 0.23
Dhankuta	Dhankuta (N); Bhedetar (N); Hile (N)	0.27; 0.67; 0.22
Sankhuwasabha	Chainpur (M); Chainpur (N); Tumlintar (N); Khadbari (M); Khadbari (N)	0.64; 0.28; 0.20; 0.47; 0.17
Pachthar	Ravi (N)	0.16
Taplegunj	Taplegunj (M); Taplegunj (N)	0.22; 0.10
Terathum	Terathum (P)	0.10
Bhojpur	Bhojpur (M); Bhojpur (N); Bhojpur (P)	0.54; 0.10; 0.46
Bhojpur	Twaribhanjyang (M); Twaribhanjyang (N)	0.17; 0.57
Bhojpur	Jarayotar (M); Jarayotar (N); Jarayotar (P)	0.53; 0.25; 0.12
Illam	Illam (M); Illam (N); Illam (P); Phikal (N); Maidhar (P)	0.4; 0.32; 0.16; 0.42; 0.16
Siraha	Siraha (M); Siraha (N); Siraha (P); Lahan (N); Lahan (P); Mirchaiya (M); Mirchaiya (N); Mirchaiya (P)	0.45; 1.80; 0.12; 1.11; 0.78;0.60; 0.12; 0.11
Okhaldhunga	Okhaldhunga (M); Okhaldhunga (N); Okhaldhunga (P); Manebhanjyang (M); Manebhanjyang (N); Manebhanjyang (P); Chitre (M); Chitre (N); Chitre (P)	0.57; 1.05; 0.12; 0.53; 0.44; 0.23; 0.19;0.47;0.33
Khotang	Diktel (N)	0.13
Khotang	Haleshi (M); Haleshi (N); Haleshi (P); Nautala (N)	0.45;0.60; 0.28;0.31
Solukhumbu	Patale (M); Patale (P); Salleri (M); Salleri (N); Faflu (M); Faflu (N); Faflu (P)	0.33; 0.26; 0.30; 0.41; 0.54; 0.57; 0.59

Water Sources Category: M: Municipal Water; N: Natural Water Source; P: Package Bottle Water

Table 2. Fluoride Concentration in mg/L (ppm) of different regions and different sources .

Resources	N	Minimum	Maximum	Median	Mean	Std. Deviation
Himalayan Region	27	<0.05	0.64	0.17	0.2237	0.19506
Hill Region	72	<0.05	1.05	0.10	0.2097	0.21965
Terai Region	45	<0.05	1.80	0.07	0.1873	0.32604
Municipal Supply System	48	<0.05	1.11	0.09	0.2340	0.25246
Natural Resources	48	<0.05	1.80	0.13	0.2490	0.31178
Packaged Water	48	<0.05	0.78	0.05	0.1331	0.15790
Overall Eastern Development Region	144	<0.05	1.80	0.08	0.2053	0.25250

Table 3.Comparison of fluoride concentration in different water sources.

Different Water Resources		N	Mean Rank	p value
Fluoride Concentration in mg/L (ppm)	Municipal Supply System Water	48	77.85	0.015*
	Natural Resources	48	80.94	
	Packaged Drinking Water	48	58.71	
	Total	144		
Water Sources of Different Regions		N	Mean Rank	p value
Fluoride Concentration in mg/L (ppm)	Himalayan Region	27	79.85	0.161
	Hill Region	72	75.56	
	Terai Region	45	63.20	
	Total	144		

*p value<0.05 is statistically significant(Kruskal Wallis test)

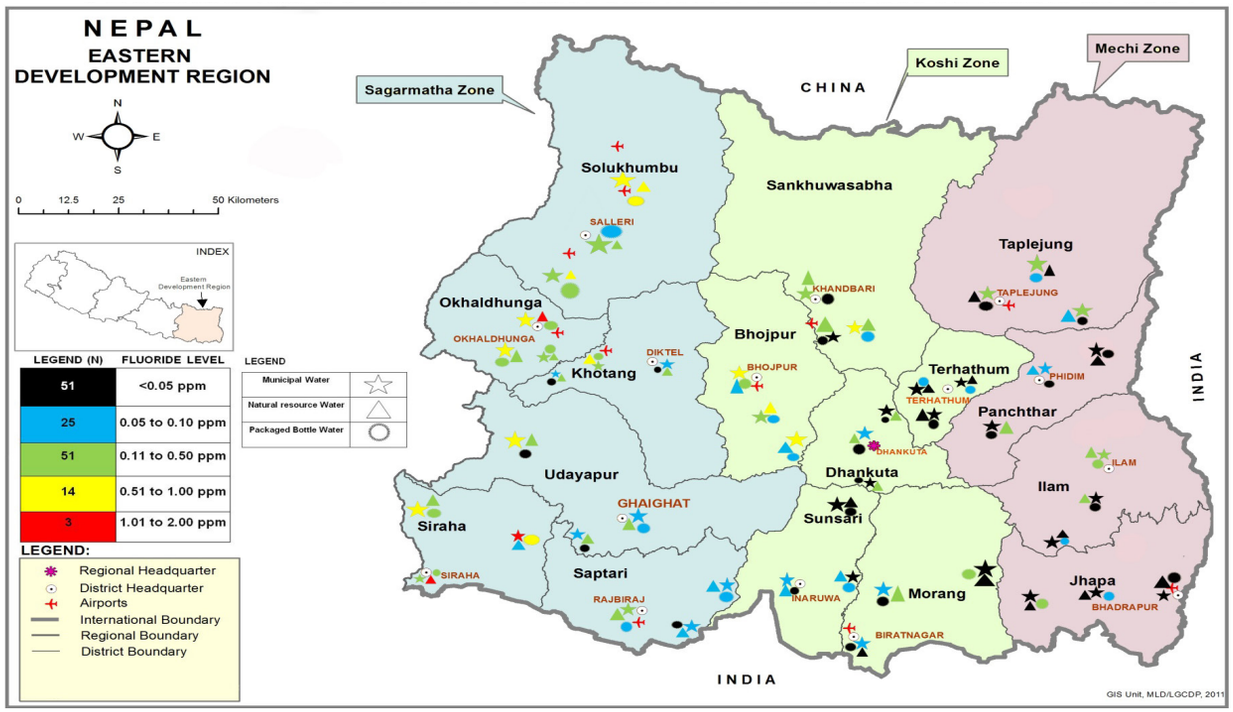


Figure 1. Fluoride mapping of eastern development region Nepal.

DISCUSSION

Fluoride is essential for prevention of dental caries. Optimum fluoride level is beneficial however lower level promotes dental caries and higher level causes dental and skeletal fluorosis.[2] Hence, fluoride is even regarded as "Double-edged Sword" and maintenance of its optimum level in drinking water is of utmost importance.[2] In Nepal, there have been researches to see the total dissolved solute in drinking water resources but focus to the importance of fluoride has been lacking. There is no national baseline data for fluoride level in various drinking water resources. This is the first study done covering such a large area to determine the concentration of fluoride in different drinking water resources of eastern Nepal.

In the present study median fluoride concentration was 0.08 ppm (<0.05 pmm to 1.80 ppm). Highest fluoride level (1.80 ppm) was in natural water resource (handpump) of Siraha municipality. The lowest fluoride level was <0.05ppm in 35.4% of the total samples analyzed.[2,5-7]

The American Dental Association advocates fluoridation of community water supplies in order to adjust the natural level of fluoride to a concentration sufficient to protect against tooth decay (0.7 to 1.2 ppm).[8] Due to the larger amount of water consumption in the hot climate compared to the temperate zones recommended level of fluoride in the water for warm tropical area should be in the range of 0.6–0.7 ppm.[7,9] In the present study, the variation of fluoride concentration was observed from mountain region with low temperature to the plain area with high temperature. Median fluoride concentration of mountain region was higher 0.17 ppm (<0.05 to 0.64 ppm) compared to the terai region 0.07 ppm (<0.05 to 1.80 ppm). The difference in fluoride level of different regions was not statistically significant (p=0.161).This result might be due to the reason that most of the packaged bottle water were seen to be manufactured in terai regions and transported to hill and the himalayan region.

Median fluoride concentration of the packaged drinking water was less compared to the municipal supply whereas natural resources were with highest fluoride concentration. The fluoride concentration of drinking water is lost due to purification processes.[10] This might be the reason of gradual decrease in fluoride concentration of municipal followed by packaged bottle drinking water when compared with natural water resources. Moreover, none of the packaged bottle water had fluoride concentration leveled in their cover. The fluoride concentration of packaged bottle water ranged from <0.05 ppm to 0.78 ppm. The difference of fluoride level in various categories of drinking water resources were found to be statistically significant (p=0.015) which was similar to the results obtained by Dhingra *et al* and Bhalla *et al*.[11,12]

There are some limitations during the study as well. There is a wide variation in the geographic location of

the water resources even within few kilometers within a district and the temperature fluctuates accordingly with altitude. However, only three samples of each category were collected from a district. Hence, there might be variation of fluoride concentration accordingly that needs more extensive sampling for further fluoride level estimation and analysis.

CONCLUSIONS

This study concluded that most of the drinking water resources of eastern Nepal had fluoride concentration below the recommended optimum level. The prevalence of dental caries is high in Nepal and fluoride helps in prevention of dental caries. Hence, there is need for further evaluation of fluoride concentration in different drinking water resources in Nepal along with advocacy for drinking water fluoridation. This is first study of its kind done to evaluate the fluoride concentration in Nepal. Hence, this study gives an idea to the policy makers to focus on the water fluoridation for prevention of dental caries to minimize the oral health burden.

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