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Assessment of fluoride level in drinking water sources in Sudurpaschim Province, Nepal

Naresh Prasad Joshi,[1] Jagadish Joshi,[2] Abanish Singh[3]

[1]Chitwan Medical College, Chitwan, Nepal, [2]Health Directorate, Doti, Sudurpashchim [3]National Medical College, Birgunj, Nepal.

ABSTRACT

Background: Fluoride, a naturally occurring element found in varying concentrations in water, confers preventive effects in dental caries around a concentration of 1 ppm. The study aimed to assess the level of fluoride in drinking water sources in the Sudurpashchim Province of Nepal.

Methods: A cross-sectional study was conducted from April to July 2023 with water samples from natural, municipal, and packaged sources collected in polypropylene plastic bottles from all 9 districts of the province. Three samples from each district's two most populous municipalities (one urban and one rural municipality) were taken. Water samples from the only sub-metropolitan city in the province (Dhangadhi) were also included. Fifty-seven samples were sent to a Nepal Standard-certified lab in Kathmandu for fluoride estimation using the American Public Health Association-approved method. Data were entered in Microsoft Excel and analysed using the Statistical Package for Social Sciences v 22. A p-value less than 0.05 was taken as significant.

Results: Most of the water samples had fluoride levels below 0.1 ppm. The highest fluoride concentration was seen in a sample from a hand pump in the rural municipality of Kanchanpur (0.9 ppm). No significant differences were observed between water samples according to different water sources, geographical regions, or categories of water resources.

Conclusions: Fluoride concentration in water sources of Sudurpashchim is well below the recommended level for caries protection. Measures should be taken to ascertain people get adequate fluoride as needed.

Keywords: Fluoride; Nepal; sudurpashchim; water fluoridation; water sources.

INTRODUCTION

Fluorine, a highly reactive chemical element, exists as fluoride in varying concentrations in water.[1] Surface water is normally low in fluoride while groundwater can contain higher concentrations of fluoride depending on geological conditions.[2] Fluoride has been known to confer preventive effects in dental caries and water fluoridation programs have been run since 1945 in the United States of America.[3]

Marked as one of the top 10 preventive approaches of the 20th century by the Centre for Disease Control and Prevention (CDC),[4] knowledge of its existing concentration in water helps plan preventive approaches.[3] The data on fluoride concentration in water can provide a baseline if water fluoridation programs are planned. World Health Organization's resolution on oral health, 2020 has also urged its member states to map and track the concentration of fluoride in drinking water.[5]

So, this study has been conducted to fill this lacuna through meticulously planned research to assess the concentration of fluoride in different water sources in Sudurpashchim province.

METHODS

This was a quantitative cross-sectional study. This study estimated fluoride levels in different water sources of the Sudurpashchim Province of Nepal. The natural, municipal, and bottled drinking water sources in Sudurpashchim province were used for fluoride estimation.

Water from natural, municipal, and packaged sources

Correspondence: Dr Naresh Prasad Joshi, Chitwan Medical College, Chitwan, Nepal, Email: nareshjoshi.mds@gmail.com, Phone: +9779852056365.

from selected Urban and rural municipalities of the province was collected. Inaccessible water sources and the sources known to be contaminated from human excreta and industrial byproducts were excluded.

Three categories of water samples including municipal water supply, natural sources like rivers, springs, wells, hand pumps, etc. and packaged bottled water available locally were collected from selected rural municipalities and rural municipalities from all nine districts of the province along with a sub-metropolitan city. Samples were collected from one rural and one urban municipality with the highest population from each district. Therefore, a total of 57 (3*2*9+3) water samples were collected. Sudurpashchim province has 9 districts and 88 local levels (one sub-metropolitan city, 33 urban municipalities, and 54 rural municipalities). In the case of Kailali, Dhangadhi sub-metropolitan city along with one urban and rural municipality was sampled. In municipalities where the municipal water system was being built, a water sample was taken from a source nearest to the building site.

One hundred and twenty ml water samples were collected in clean polypropylene plastic bottle vehicles. The bottle vehicles were appropriately marked with a code and were stored at room temperature. The samples were transported to CEMAT Water Lab Pvt. Ltd. Kathmandu for estimation of fluoride within 15 days 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 the laboratory for analysis.

American Public Health Association (APHA) 4500 F- D method of fluoride estimation was used for fluoride estimation.[6] It is a colourimetric method based on the reaction between fluoride and a zirconium-dye lake. Fluoride concentration was recorded in parts per million (PPM) and mg/dl.

A total of 10 % of water samples were retested to check for reliability.

Ethical approval was obtained from the Nepal Health Research Council before data collection. (Ref No. 2798). This study was conducted in the Sudurpashchim province of Nepal from April to July 2023.

Collected data were entered into Microsoft Excel 2016 and statistical analysis was done using Statistical Package for Social Sciences (SPSS) v. 22. Mean, standard deviation, median, percentage, and proportion were calculated and data were presented in graphical and tabular form. A comparison of mean fluoride concentrations was done using the Kruskal-Wallis test. A p-value <0.05 was taken as significant.

RESULTS

This study was conducted to assess the fluoride level in drinking water sources of Sudurpashchim province, Nepal. A total of fifty-seven samples were collected and analysed for fluoride level. Most of the water samples had fluoride levels below 0.1 ppm whereas, among the analysed samples, the maximum level of fluoride level was 0.9 ppm of the water supply system (source: hand pump) from Laljhadi, Kanchanpur. [Table 1] Fluoride concentration in different drinking water sources of the province has been listed in table 1, 2, and 3.

Table 1.Fluoride concentration in districts of Terai Region of Sudurpashchim Province.

SN	District	Municipality	Category	Fluoride Concentration in mg/L (ppm)
1	Kailali	Dhangadi	Municipal	0.2
2			Natural	<0.1
3			Packaged	0.3
4		Godawari	Municipal	<0.1
5			Natural	0.1
6			Packaged	<0.1
7		Kailari	Municipal	0.6
8			Natural	0.2
9			Packaged	<0.1
10	Kanchanpur	Bheemdatt	Municipal	<0.1
11			Natural	0.1
12			Packaged	<0.1
13		Laljhadi	Municipal	0.9
14			Natural	0.4
15			Packaged	<0.1

Table 2.Fluoride concentration in districts of Hilly Region of Sudurpashchim Province.

SN	District	Municipality	Category	Fluoride Concentration in mg/L (ppm)
1	Doti	Dipyal Silgadi	Municipal	<0.1
2			Natural	<0.1
3			Packaged	<0.1
4		Adarsha	Municipal	<0.1
5			Natural	0.1
6			Packaged	<0.1
7	Dadheldhura	Parsuram	Municipal	<0.1
8			Natural	<0.1
9			Packaged	<0.1
10		Nawadurga	Municipal	<0.1
11			Natural	<0.1
12			Packaged	<0.1
13	Baitadi	Purchaudi	Municipal	0.2
14			Natural	0.1
15			Packaged	0.1
16		Dogdhakedar	Municipal	0.1
17			Natural	0.1
18			Packaged	<0.1
19	Achham	Mangalsen	Municipal	0.2
20			Natural	0.2
21			Packaged	<0.1
22		Turmakhand	Municipal	0.1
23			Natural	0.2
24			Packaged	<0.1

Table 3. Fluoride concentration in districts of Mountainous Region of Sudurpashchim Province.

SN	District	Municipality	Category	Fluoride Concentration in mg/L (ppm)
1	Bajhang	Bungal	Municipal	0.1
2			Natural	0.1
3			Packaged	<0.1
4		Bitthadchir	Municipal	0.3
5			Natural	0.3
6			Packaged	<0.1
7	Bajura	Budhiganga	Municipal	<0.1
8			Natural	<0.1
9			Packaged	<0.1
10		Chhededaha	Municipal	0.1
11			Natural	<0.1
12			Packaged	0.1
13	Darchula	Mahakali	Municipal	<0.1
14			Natural	<0.1
15			Packaged	<0.1
16		Malikarjun	Municipal	<0.1
17			Natural	<0.1
18			Packaged	<0.1

The mean fluoride concentration was highest among the municipal water compared to the natural and packaged drinking water sources. (Table 4 and Figure 1)

Table 4.Fluoride Concentration According to Category of Water Resources						
Resources	N	Minimum	Maximum	Median	Mean	Std. Deviation
Municipal Supply System	19	<0.1	0.9	0.1	0.19	0.20
Natural Resources	19	<0.1	0.4	0.1	0.15	0.09
Packaged Water	19	<0.1	0.3	0.1	0.11	0.04
Overall	57	<0.1	0.9	0.1	0.15	0.13

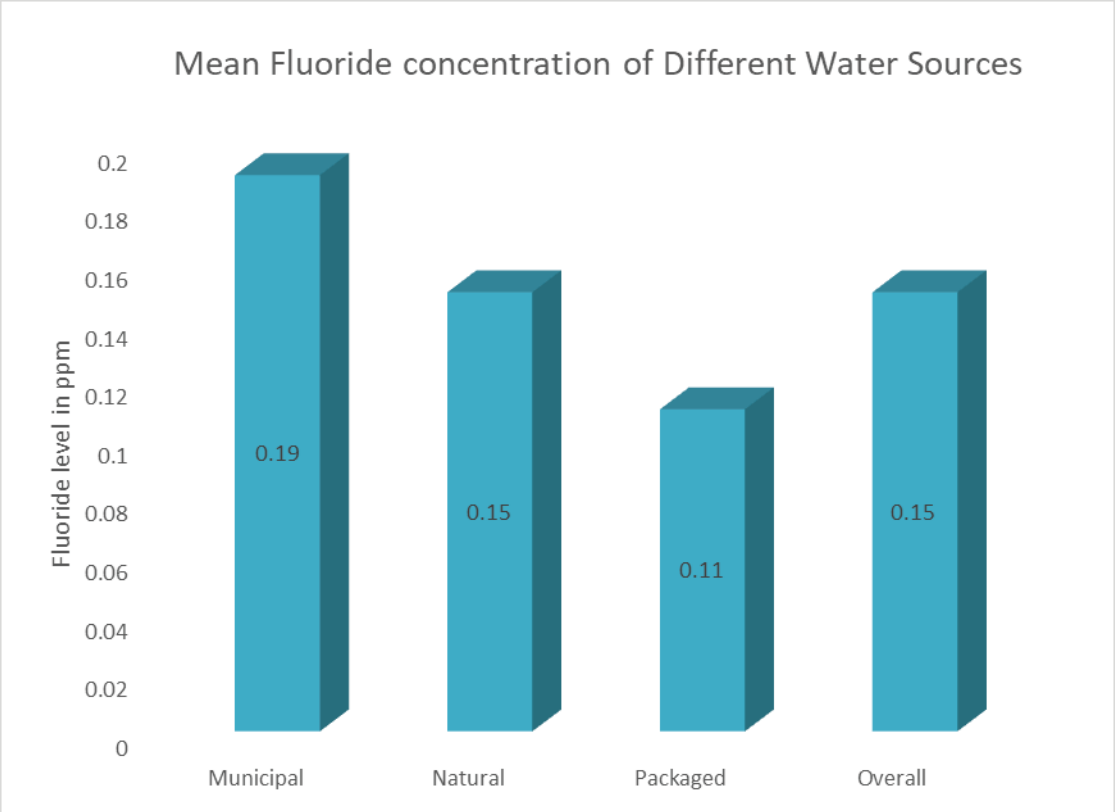

Figure 1. Mean fluoride Concentration of the different water sources.

When compared among the municipal, natural and packaged water samples there was no statistically significant difference in the fluoride concentration (p=0.12). (Table 5)

Table 5. Comparison of Fluoride Concentration in Different Water Sources.				
Different Water Sources		N	Mean Rank	p-value*
Fluoride Concentration In mg/L (ppm)	Municipal Supply System Water	19	32.1	0.12
	Natural Resources	19	30.29	
	Packaged Drinking Water	19	24.58	
	Total	57		

*Kruskal-Wallis Test

Similarly, no statistically significant difference was observed between water sources according to different geographic region of the province. (Table 6)

Table 6. Comparison of Fluoride Concentration in Different Geographic Regions.

Different Geographic Region		N	Mean Rank	p-value*
Fluoride Concentration In mg/L (ppm)	Terai	15	35.00	0.70
	Hills	24	27.25	
	Mountains	18	26.33	
	Total	57		

*Kruskal-Wallis Test

DISCUSSION

This study estimated fluoride levels in drinking water sources of Sudurpashchim province. According to the Nepal Health Demographic Survey 2022, nearly the entire population (98%) in Nepal has access to at least basic drinking water services.[7] This study consisted of water samples from municipal water sources, natural water sources and bottled water sources. All but one water source contained fluoride at less concentration than is recommended by the American Dental Association (ADA) for preventing dental caries. The only sample with the recommended level of fluoride was collected from a hand pump near the construction site of the Community water supply in Laljhadi Rural Municipality of Kanchanpur.

Previous studies to estimate water fluoride in Nepal have produced similar results. Fluoride concentration below the recommended level has been found in studies in Kathmandu, Gulmi, and Eastern Development region of Nepal.[8-10] Groundwater sources generally have lower while underground sources can have lower or higher concentrations depending on the nature of the rocks and the occurrence of fluoride-bearing minerals.[11] Our neighbour to the south, India, is known to have high fluoride content in certain regions of the country.[12] We also found the highest concentration of fluoride towards the southern part of the province. It may be worthwhile to invest in estimating fluoride content from the districts from Terai in Nepal. People use underground water sources in these regions.

Fluoride concentration of municipal, natural and packaged water was not found to be statistically different. Previous studies have found statistical differences between community water supply and bottled water.[6, 12] This difference can be because of the source of community water supply. Even if underground water sources have high fluoride concentrations, it can be lost during the purification process.[14]

Sudurpashchim is made up of plain (Terai), hills and mountains. This study incorporated samples from all three regions of the province. Out of 9 districts, 2 are in the plains, 4 in the hilly and 3 in the mountainous region of the province. All the water sources in the plain region were groundwater while hills and mountainous region sources included rivers, streams and springs. However, fluoride concentration did not differ significantly according to different geographic regions of the province.

Fluoride prevents dental caries in all age groups.[15] But water sources in Sudurpashchim do not have enough fluoride to confer caries protection. These findings reiterate the importance of using fluoridated toothpaste, professional application of fluoride in children and other modes of interventions like pit and fissure sealant application to prevent caries in children.

Moreover, as Nepal is undergoing significant changes in its governing system and federal, provincial and local governments are starting to find their feet, this is an opportune time to work towards water fluoridation.

In this study, only 19 municipalities out of 88 were selected and 3 samples from each municipality were taken. Fluoride levels in water may differ among different sources. Also, not all rural municipalities had municipal water supply. In such cases, water from the nearest source to the construction site of the municipal water supply was collected. This study does provide a picture of fluoride levels in different water sources of all three geographic regions of the province.

CONCLUSIONS

The fluoride concentration is lower than recommended in the selected drinking water sources of Sudurpashchim. This study suggests the need for more extensive sample collection and surveys at the national level. The consequences of the low fluoride and high fluoride in water can have a long-term effect on the longevity of teeth affecting the overall health of an individual. Hence, timely estimation of fluoride concentration in drinking water resources and maintenance of its optimum level is recommended. Approaches whenever possible as treatment approaches are often expensive.

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