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Original Article

Dentistry Section

Level of Fluoride in Soil, Grain and Water in Jalgaon District, Maharashtra, India

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ABSTRACT

Introduction: Fluoride has an influence on both oral as well as systemic health. The major source of fluoride to body is through drinking water as well as through diet. Staple diet mainly depends on local environmental factors, food grains grown locally, its availability etc. Determination of fluoride level in these food grains is important. So, estimation of the amount of fluoride in grains and its relation to the sources of fluoride used for their cultivation viz., soil and water is important.

Aim: To estimate the relation of fluoride concentration in grains (Jowar) with respect to that of soil and water used for their cultivation.

Materials and Methods: Fifteen samples each of soil, water and grains were collected using standardized method from the same farm fields of randomly selected villages of Jalgaon district. Fluoride ion concentration was determined in laboratory using SPADNS technique. Mean difference in fluoride levels in between the groups were analyzed using ANOVA and Post-Hoc Tukey test. Linear regression method was applied to analyse the association of the fluoride content of grain with water and soil.

Results: There was a significant difference in between mean fluoride levels of soil and water ($p<0.001$) and in between soil and grain ($p<0.001$); however, difference in between mean fluoride levels of water and grain was found to be non significant ($p=0.591$). Also fluoride levels in all the three groups showed significant association with each other.

Conclusion: Fluoride level of soil, grains and water should be adjusted to an optimum level. Soil has positive correlation with respect to uptake of fluoride by Jowar grains. So, Jowar grains with optimum fluoride content should be made available in the commercial markets so that oral and general health can be benefitted.

Keywords: Black soil, Fluorosis, Jowar grain, Water

INTRODUCTION

Fluoride, an ionic form of fluorine, is widely distributed in atmosphere. Fluoride is associated with two of the most common dental diseases i.e., dental caries and dental fluorosis which are considered as public health problems in India [1]. Drinking water is considered as the major source of fluoride to the body. Optimum fluoride level in water will control dental caries without causing dental fluorosis. Fluoride concentration in water is directly proportional to dental fluorosis and inversely related to dental caries. It has been proven through extensive research that optimum concentration of fluoride is required in drinking water to maintain the integrity of oral tissues [2,3].

Sources of fluoride other than water include exposure to dietary fluoride and fluoridated toothpaste. The intake of fluoride varies widely according to the various sources of exposure [4-6]. All vegetation contains some amount of fluoride, which is absorbed from the soil and water [7]. Various factors that contribute to the fluoride concentration in food include the location where the food was grown and the use of fluoride containing fertilizers and pesticides. Food grown in areas where soils have high amounts of fluoride, or where phosphate fertilizers are used, may have higher levels of fluoride [8,9]. Even the fluoride level of water used to prepare or process food also contributes to the fluoride concentration of a particular food.

Soil serves as vital function in nature, providing a medium for plant growth as well as nutrients for plants. Soil is main factor that controls the quality of water. Climatic conditions, composition of the host rock and hydrogeology have an influence on amount of fluoride occurring in ground water. Anthropogenic activities such as use of phosphate fertilizers, pesticides, sewage and sludge for agriculture, depletion of groundwater, etc., are also responsible for increased fluoride concentration in groundwater. When groundwater is used in irrigation, the vegetables/grains grown also incorporate this fluoride apart from other sources. Fluoride is mainly absorbed by plant roots from where it is transported to transpiratory organs, such as leaves, where it can be accumulated [10].

Thus, the journey of fluoride tends to continue from the parent rock into the soil, water, plants grains and ultimately reaches to the human beings through their diet. Jowar is one of the staple foods of Maharashtra [11]. Studies have shown that fluoride retention is greater in Jowar due to presence of molybdenum and molybdenum increases fluoride retention in the body [12]. Several scientific literatures about the fluoride content of the drinking water is available and much less has been reported on concentration of fluoride in soil and the fluoride content of the foodstuffs in fluoride contaminated areas. This provided an impetus with the aim to estimate the amount of fluoride in grains, soil and water.

MATERIALS AND METHODS

This study was an in-vitro study conducted on soil, grain and water samples of 15 villages of Jalgaon district in Maharashtra, India. The study was carried out at Department of Public Health Dentistry, ACPM Dental College, Dhule, Maharashtra, India. Permission to conduct the study was obtained from Institutional Ethical Clearance Committee of ACPM Dental College and Hospital, Dhule. Jalgaon district consists of 15 talukas/tehsils and one village from each taluka was chosen randomly for the present study. From each selected village, a sample each of soil grain and water was collected.

Collection and Analysis of Soil: Soil samples were collected from 15 different croplands which were used for the cultivation of Jowar crop. Soil samples were collected from immediate adjacent areas of the roots of the crop within a depth range of 1.0 to 30.0 cm. The surface of each soil sample was checked to confirm that it was free of stocks, remains of plants or other debris. The soil samples were obtained by digging vertically and collecting from distinct horizons. The samples were transported to the laboratory in plastic bags. The soil samples were finely grinded and sieved with mesh (size less than 2 mm) and the homogenized soils were sub sampled for digestion. About 50 g of each soil sample was digested with aqua regia. The digested sample was cooled and was filtered using Whatman No.1 filter paper into a flask [13,14]. After filtration, fluoride concentration was analyzed by SPADNS spectrophotometric method.

Collection and Analysis of Grains: Jowar grains were harvested from the Jowar plant from the selected farm itself. Care was taken that no other parts of plant were present. The samples were kept in plastic bags and transported to the laboratory. Samples were washed with distilled water, dried in an oven at 105ºC for 24 hour and then crushed into a powder so as to pass through a 40 mesh sieve. About 0.5 g each of the powdered sample was transferred into a 150 ml nickel crucible and moistened with a small amount of de-ionized water. A 6 ml of 16.8 N NaOH was added and crucible was placed in muffle furnace and slowly raising the temperature to 600°C for half an hour, followed by dissolving the residue by heating with water on a hot plate. After the treatment samples were removed, allowed to cool and then 10 ml of distilled water was added to the samples with stirring to adjust the pH to 8–9. The sample solution was transferred to a 100 ml plastic volumetric flask, made upto volume with distilled water and filtered through a Whatman No. 40 filter paper [15]. The filtrate was used for analysis of fluoride using SPADNS method.

Collection and Analysis of Water: One liter of well water which was used for cultivation of the crops was collected and transported to the laboratory. Water was collected in pre-cleaned sterilized polythene bottles as per the standard protocol. Water samples were analyzed for fluoride content using SPADNS method.

All the samples were precoded from 1 to 15 and not disclosed to the technician and the statistician so as to eliminate any potential bias.

STATISTICAL ANALYSIS

Collected data was complied, tabulated and analyzed using SPSS 17 software. Mean difference in fluoride levels in between the groups were analyzed using ANOVA and Post hoc Tukey test. Linear regression method was applied to analyse the association of the fluoride content of grain with water and soil.

RESULTS

The results of the present study showed that mean fluoride level of soil was 2.631 ppm, that of water was 1.637 ppm and for grains was 1.435 ppm [Table/Fig-1]. There was statistically highly significant ($p<0.01$) difference of mean fluoride levels in between the three groups [Table/Fig-1]. Fluoride concentration showed significant difference in all comparison except between water vs grain [Table/Fig-2].

Variables	N	Mean Fluoride level (ppm)	SD
Water	15	1.637	0.477
Soil	15	2.631	0.726
Grain	15	1.435	0.441
ANOVA		f-value: 19.422	p-value = 0.001*

[Table/Fig-1]: Mean level of fluoride in water, soil and grains.
* The mean difference is significant at the 0.05 level.

Variables	Mean Difference	Standard Error	p-value
Water vs Soil	-0.994	0.205	0.001*
Water vs Grain	0.202	0.205	0.591 (NS)
Soil vs Grain	1.196	0.205	0.001*

[Table/Fig-2]: Difference of mean fluoride level in between water, soil and grains.
* The mean difference is significant at the 0.05 level; NS – Non significant difference
Post hoc Tukey test

Variables	Water	Soil r-value (p-value)	Grain r-value (p-value)
Water	1	0.646 (p = 0.009)	0.717 (p = 0.003)
Soil		1	0.8 (p = 0.001)
Grain			1

[Table/Fig-3]: Correlation of fluoride level in water, soil and grain fluoride content.
Pearson correlation test

Variables	Univariate analysis		Adjusted analysis	
	β-value	p-value	β-value	p-value
Soil vs water	0.984	0.009	--	--
Soil vs Grain	0.485	0.001	0.350	0.016
Water vs Grain	0.663	0.003	0.319	0.118

[Table/Fig-4]: Regression analysis of the fluoride level in water, soil and grain.
Linear regression analysis

Fluoride levels in all the three groups showed significant association with each other. Maximum association was seen among fluoride level of soil and grain (r-value = 0.8) [Table/Fig-3]. Univariate linear regression analysis demonstrated a strong association (β=0.984) of fluoride level between soil and water. The strength of association of fluoride level between soil and grain decreased when adjusted for the fluoride level in water (β= 0.350). Similarly, the strength of association of fluoride level between water and grain decreased severely when adjusted for the fluoride level in soil (β=0.319) [Table/Fig-4].

DISCUSSION

Endemic fluorosis has remained a major public health problem throughout the world, especially in India [16]. Absolute treatment is difficult, hence prevention and control of fluorosis is important, thus changing the water source, reducing the fluoride concentration of drinking water and decreasing the consumption of fluoride rich food are the main strategies that can effectively diminish the incidence of fluorosis. It is the total amount of Fluoride absorbed in a human body that needs to be considered i.e., the sum of fluoride intake from water, food, and air. Therefore, determining dietary fluoride intake is also useful and important for estimating the retention of fluoride in man [17]. This provided an impetus with the aim to estimate the absorption of fluoride to edible grains from soil and water.

In the present study, the mean fluoride level of water used for irrigation was found to be 1.63 ppm and is above the permissible limit. The amount of fluoride concentration in water differed from place to place; this may be attributed to factors such as hydrological condition, land form, rainfall, evaporation and also adsorption and leaching of fluoride in soil [18]. The fluoride level of soil was found to be 2.631 ppm. This is in accordance with the study conducted by Abida Begum 2012 in which the fluoride concentration of black soil obtained from five agricultural locations across Mysore district was in the range of 2.3-4 mg/l [14]. In a study conducted by Wang et al., it was found that the ability of black soil to absorb fluoride was higher than other soils [18]. This may be a probable reason for high amount of fluoride in soil tested in present study. The mean fluoride concentration in the Jowar grain was found to be 1.435 ppm. The results of the present study could not be compared with other studies as to our best knowledge, till date, no previous research has been done to assess the fluoride level in jowar grains. The amount of fluoride present in Jowar grains may be due to uptake from the soil or from water used for irrigation and it may also be attributed to presence of molybdenum in Jowar grain which helps in retention of fluoride ions [12]. Fluoride levels in all the three groups showed significant association with each other with maximum association being found in fluoride levels of soil and grain (r=0.8).

Soil fluoride level was found to be higher than grain and water fluoride level. This may be attributed to presence of naturally occurring fluoride in the soil in the form of minerals as well as release of fluoride in the soil from anthropogenic activities such as application of fertilizers and aluminum smelting industrial emissions [13]. While the uptake of fluoride by plant is dependent on a number of factors i.e., soil pH, soil type and presence of other elements [18,19]. From the results, it can be seen that grain derives almost equal fluoride content from both soil and water (adjusted regression analysis in [Table/Fig-4]) and it is also clear that fluoride content of the grains cultivated in fluorosis prone area (having high amount of fluoride in soil and water) is on the higher side (1.435 ppm).

Thus, fluoride accumulation in the people residing in fluorosis prone area can be attributed to consumption of grain containing high amount of fluoride in addition to fluoride contaminated drinking water (above permissible limits). Gupta S et al., conducted a study to determine fluoride intake through meal, vegetables and drinking water [17]. The results showed that fluoride uptake accounted for 26%, 30% and 44% of the total fluoride amount, respectively for meal, vegetables and drinking water. Thus, it can be seen that substantial amount of fluoride was ingested through meals and vegetables (56%) apart from drinking water.

The use of fluoride containing water for irrigation for crops that tend to accumulate fluoride should be reduced as much as possible in order to reduce the risk of human exposure to fluoride. However, in areas where only fluoride contaminated irrigation water is available then it is advisable to grow crops with relatively low capabilities to enrich fluoride or crops having high fluoride levels can be transported for consumption in those regions which are having deficient levels of fluoride in drinking water. Also, the farmers should analyse for the fluoride levels in the soils before using fertilizers which could prevent additional source of fluoride to the soil.

Further studies should be conducted with large sample size for comparison of the fluoride trend in the district as well as nearby places. Research should focus on evaluating the effect of temperature, type and amount of fertilizers used, etc., on the fluoride content of jowar grains.

LIMITATION

Various factors such as environmental conditions, type and amount of fertilizers used, amount of water used to cultivate the crops, pH of soil, etc., which may affect the fluoride absorption were not taken into consideration during this study due to financial and time constraints.

CONCLUSION

From the present study, we can conclude that water and soil fluoride levels have a great influence on fluoride concentration in grain. Use of fluoridated water for irrigation should be minimized for the crops that tend to accumulate fluoride which could result in less human exposure to excess fluoride. Authorities should take into consideration the fluoride content of jowar grains before selling it in the market.

REFERENCES

[1] Kotecha PV, Patel SV, Bhalani KD, Shah D, Shah VS, Mehta KG. Prevalence of dental fluorosis and dental caries in association with high levels of drinking water fluoride content in a district of Gujarat, India. Indian J Med Res. 2012;135(6):873-77.

[2] Petersen PE, Lennon MA. Effective use of fluorides for the prevention of dental caries in the 21st century: The WHO approach. Community Dent Oral Epidemiol. 2004;32:319–21.

[3] Fluorides and oral health [Internet]. Geneva: WHO; 1994 [cited 2016 June 20]. Available from: http://apps.who.int/iris/bitstream/10665/39746/1/WHO_TRS_846.pdf.

[4] Malde MK, Måge A, Julshamn K, Macha E, Bjorvatn K. Fluoride content in selected food items from five areas in East-Africa. J Food Comp Anal. 1997;10:233-45.

[5] Malde MK, Scheidegger R, Julshamn K, Bader HP. Substance flow analysis: A case study for fluoride exposure through food and beverages in young children living in Ethiopia. Environ Health Perspect. 2011;119:579-84.

[6] Vitoria I. Oral fluoride including drinking water in prevention of tooth decay. Int J Food Sci Nutr Diet. 2015;4(3):197-201.

[7] Fawell J, Bailey K, Chilton J, Dahi E, Fewtrell L, Magara Y. Fluoride in drinking-water. World Health Organization. London: IWA Publishing; 2006.

[8] Adair SM, Bowen WH, Burt BA, Kumar JV, Levy SM, Pendrys DG. Recommendations for using fluoride to prevent and control dental caries in the United States. MMWR Morb Mortal Wkly Rep. 2001;50(No. RR-14):8-10.

[9] Public Health Service Agency for Toxic Substances and Disease Registry USA. Toxicological profile for fluorides, hydrogen fluoride, and fluorine [Internet]. Atlanta: Agency for Toxic Substances and Disease Registry (ATSDR); 2003 [cited 2016 Jun 21]. Available from: www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=212&tid=38.

[10] Pal KC, Mondal NK, Bhaumik R, Banarjee A, Datta JK. Incorporation of fluoride in vegetation and associated biochemical changes due to fluoride contamination in water and soil: A comparative field study. Annals of Environmental Science. 2012;6:123-39.

[11] Misra A, Rastogi K, Joshi RK. Whole grains and health: Perspective for Asian Indians. J Assoc Physicians India. 2009;57:155-62.

[12] Khandare AL, Suresh P, Kumar PU, Lakshmaiah N, Manjula N, Rao GS. Beneficial effect of copper supplementation on deposition of fluoride inbone in fluoride- and molybdenum-fed rabbits. Calcif Tissue Int. 2005;77(4):233-38.

[13] Abugri DA, Pelig-Ba KB. Assessment of fluoride content in tropical surface soils used for crop cultivation. Afr J Environ Sci Technol. 2011;5(9):653-60.

[14] Begum A. Soil profiles and fluoride adsorption in intensely cultivated areas of Mysore District, Karnataka, India. Chem Sci Trans. 2012;1(2):410-14.

[15] Malde MK, Bjorvatn K, Julshamn K. Determination of fluoride in food by the use of alkali fusion and fluoride ion-selective electrode. Food Chem. 2001;73:373-79.

[16] Khairnar MR, Dodamani AS, Jadhav HC, Naik RG, Deshmukh MA. Mitigation of fluorosis – A Review. J Clin Diagn Res. 2015;9(6):ZE05-ZE09.

[17] Gupta S, Banarjee S. Fluoride accumulation in crops and vegetables and dietary intake in a fluoride-endemic area of West Bengal. Fluoride. 2011;44(3):153–57.

[18] Wang W, Li R, Tan J, Luo k, Yang L, Li H, et al. Adsorption and leaching of fluoride in soils of China. Fluoride. 2002;35(2):122-29.

[19] Ruan J, Ma L, Shi Y, Han W. The impact of pH and calcium on the uptake of fluoride by tea plants (Camellia sinensis L.). Ann Bot. 2004;93(1):97–105.

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