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Fluoride incorporation on selected vegetables in cultivated areas of Kamrup District of Assam

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Abstract: *Along with ground water, vegetable is also a common source of fluoride in human body. Five most commonly used vegetable [Tomato (Solanum lycopersicum), Brinjal (Solanum melongena), Cabbage (Brassica oleracea capitata), Potato (Solanum tuberosum), and French bean (Phaseolus vulgaris)] was selected for the study. Six samples of each vegetable were collected from six different cultivated areas of the district. Vegetable extracts were prepared using standard method and concentrations of fluoride were measured using fluoride ion selective electrode. The mean concentrations of fluoride in Tomato, Brinjal, Cabbage, Potato and French bean were recorded as 4.6mg/kg, 6.19mg/kg, 3.29mg/kg, 12.43mg/kg and 1.44mg/kg respectively. The fluoride content in soil and irrigation water is the main reason for the fluoride accumulation in the vegetable. It also depends on the affinity of the plant for the accumulation of fluoride. The Bioconcentration factor (BCF) was calculated for the samples and found the mean BCF of 2.49, 2.72, 1.9, 3.64 and 1.41 respectively in the five selected vegetables. The higher BCF values (>1) in all the samples indicated that these samples have high affinity for the fluoride accumulation. However, it also depends on the other soil properties and plant factors.*
Key Word: *Fluoride, Vegetable, Irrigation, Soil, Groundwater, BCF.*

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I. Introduction

The principal source of fluoride in human is believed to be the sources of drinking water. But in many parts of the world, elevated levels of fluoride contaminated ground water, often used for irrigation purposes, can have considerable adverse effects on the crops (Mondal and Gupta, 2015). Thus, along with drinking water, vegetables are also a source of fluoride in human body. Although fluoride is not essential element for plant but it is essential for human because both very low and very high fluoride content may have some health effects. As human depends on plant for food, vegetables may one of the source of fluoride in human body. Vegetables constitute an important item of human diet. Everyday men consume vegetables. Vegetables uptake fluoride from soil, fluoride rich ground water which is irrigated in the crop field and from the fertilizers used in agricultures. Plants also absorb fluorine from the air along with the falling atmospheric dust (Anbuvel et al., 2015). The use of fluoride enriched ground water for irrigating the crops is prevalent in many parts of the world. The fluoride in the irrigated water not only affects the growth and productivity of the crops, but also gets accumulated in plant tissues (Anasuya *et al.*, 1995). The World Health Organization (WHO,1984) and Bureau of Indian Standards (BIS, 2003) have laid down the maximum permissible limits of fluoride in drinking water as 1.5ppm and 1ppm, respectively, but there is no stringent threshold limits of fluoride in soil and plants above which the ingestion may be detrimental to human health. Potato, Tomato, Cabbage, Brinjal and French bean are the most commonly eaten vegetables in Kamrup district of Assam, India. These are rabi crops and generally cultivated in winter season and due to scarcity of rainfall in this season, farmers mostly dependent on ground water for irrigation. Again, use of phosphate fertilizers in agriculture is a common practice in the Kamrup district of Assam. Therefore, fluoride concentration in these selected vegetables is estimated in the present study. Fluorine is a non essential element for plant, but the affinity of plant to uptake and accumulate fluorine becomes a threat to human health as it enters into the food chain (Pal et al., 2012).

II. Material and Methods

Sampling: Five different vegetables were selected viz. Potato (*Solanum tuberosum*), Cabbage (*Brassica oleracea capitata*), Tomato (*Solanum lycopersicum*), Brinjal (*Solanum melongena*) and French bean (*Phaseolus vulgaris*). Winter crops were selected for the study because in winter season, due to scarcity of rainfall groundwater is used for irrigation purposes. Six different location of Kamrup district were selected for vegetable sample collection, where cultivation of vegetables was practiced on large scale. Along with the vegetables, composite soil samples were also collected from the same agricultural field. Ground water samples were also collected from the nearby sources which are used for irrigation purposes. Six samples of each selected vegetables were collected one from each location and thus a total number of 30 vegetable samples were collected in the month of February, 2017. Samples were collected freshly from the agricultural fields and carried separately in polythene packets. Then the vegetables were washed thoroughly with tap water followed by distilled water and dried in room temperature for 10minutes. After that the samples were dried in oven at 105°C and stored in clean plastic packets for further analysis.

Methodology for fluoride estimation in irrigation water: Groundwater samples were collected in 500ml sterilized polypropylene (turson made) bottles. Fluoride estimation in ground water samples were done by electrode method using Fluoride ion selective electrode (APHA, 1995). 25ml of TISAB buffer was mixed well with 25ml of sample and then fluoride concentration was measured with the help of fluoride ion selective electrode (Orion ion analyzer).

Methodology for fluoride estimation in vegetables (McQuaker and Gurney, 1977): For fluoride estimation in vegetables, collected vegetables were dried at 105°C and crushed into powder so as to pass through a 40-mesh sieve and were stored in clean dry, tightly closed plastic bottles. Further about 0.5g each of the powdered samples was transferred into a 50ml nickel crucible and moistened with a small amount of de-ionized water. Six ml of 16.8N NaOH was added and the crucible was placed in an oven (150°C) for 1.5-2.0 hour until NaOH was solidified. The crucible was placed in a muffle furnace set at 300°C, then raised to 600°C and kept at 600°C for 30minutes in order to fuse the sample in the crucible. The crucible was place in a hood and allowed to cool, and 10ml distilled water was added. Then, 37% HCl solution (about 7ml) was added slowly to adjust the pH to 7-9. The sample solution was transferred to a 100ml plastic volumetric flask, made up to volume with distilled water and filtered through a Whatman No 40 filter paper. The filtrate was used for analysis of fluoride. 10ml filtrate was taken and another 10ml TISAB solution was added to it. Then fluoride concentration was measured with a fluoride ion selective electrode using an ORION 5 star ion analyzer.

Methodology for soluble fluoride estimation in soil: The method of partial leaching described by Lori (1987) was applied in the preparation of the soil extract for analysis. The air dried soil samples were crushed to powder. 10g each of the oven dried powdered soil samples were separately weighed into a 100ml plastic beaker (turson made) and 20ml of distilled water was added. The mixtures were stirred and allowed to stand for six hours. They were filtered into a 100ml volumetric flask. The residues were leached slowly over a two hour period with distilled water on to the same filter paper and the leachate going into the same beaker containing the filtrate. The filtrates and the leachate mixture were made up to the mark with distilled water. 25ml of this extract was used for the detection. The samples and fluoride standard solutions were diluted 1:1 with the TISAB. The solutions, which contained 25ml of the sample and 25ml of TISAB solutions, were mixed with a magnetic stirrer for three minutes. The electrode potentials of the sample solutions were directly compared with those of fluoride standard solutions and the concentration of fluoride in samples were obtained. The limit of detection (LOD) of the method was 0.02 mg/L.

Statistical analysis: Statistical analyses were done using the SPSS software (version 16). One way ANOVA was carried out to study whether there is any significant difference between the mean fluoride content of different vegetables.

III. Result and Discussion

Soluble Fluoride in soil: The total fluoride concentration in the soil generally do not correlate well with the uptake of fluoride by roots presumably because it is the only fluoride in solution or easily desorbable fluoride which is taken up by the plants (Black, 1965; Cooke et al., 1976; Gisiger, 1968). Therefore soluble fluoride was determined in the soils of different agricultural fields. Fluoride concentrations in the soil samples were measured to access the translocation of fluoride from soil to plant body by calculating the BCF. The soluble F concentration in different soil samples collected from different agricultural fields is presented in table 1 to table 5. It was found that the concentration of soluble fluoride varied between 1.53mg/kg to 1.98mg/kg in tomato, 1.64mg/kg to 3.04mg/kg in brinjal, 1.29mg/kg to 1.87mg/kg in cabbage, 2.76mg/kg to 4.34mg/kg in potato and 0.63mg/kg to 1.42mg/kg in French bean. Out of the six selected location of the Kamrup district, soluble fluoride concentration in the soil of different agricultural fields are varies. This variation may be dependent on the factors such as different amount of fertilizer used, different quality of soil type and fluoride binding capacity of soil particles. Soil calcium is another factor as calcium has a strong binding capacity with fluoride and thus reduces the soil soluble fluoride. Mondal and Gupta (2015) reported soluble fluoride concentration in the range of 10.9mg/kg to 17.2mg/kg in the pre treated soil. Jha et al. (2009) in their pot experiment also reported soluble fluoride concentration of 6.01mg/kg in the control pot.

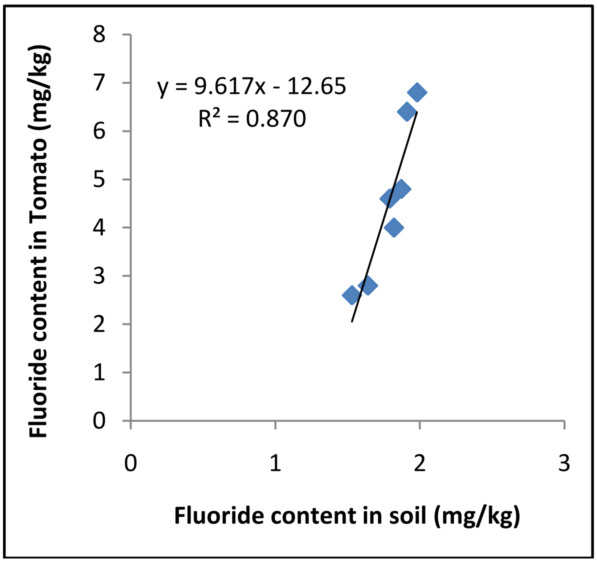
Accumulation of Fluoride in the selected vegetables: The results obtained from the analysis of total fluoride in five selected vegetable samples collected from six different locations are presented in the table 1 to table 5. Fluoride concentration is found between 2.6mg/kg to 6.8mg/kg in tomato samples, 2.56mg/kg to 10.8mg/kg in brinjal samples, 1.3mg/kg to 4.56mg/kg in cabbage samples, 9.75mg/kg to 18.6mg/kg in potato samples and 1.26mg/kg to 1.7mg/kg in bean samples. Potato shows highest fluoride concentration with average fluoride content of 12.43mg/kg. This indicates the higher affinity of fluoride uptake by potato plants. Lowest concentration of fluoride is recorded in bean samples with the mean fluoride content of 1.44mg/kg. Elevated concentration of fluoride in the irrigated ground water and soluble fluoride content in the cultivated soil are the main reason of increase concentration of fluoride in the vegetable samples. A significant positive correlation between fluoride content in soil and fluoride content of vegetables is observed (Figure 1). Mondal and Gupta (2015) reported 22.6mg/kg total fluoride in Cabbage and 2.02mg/kg soluble fluoride in Tomato. Many researchers have reported high accumulation and uptake of fluoride by different vegetables [Das et al.(2015), Pal et al.(2012), Gupta and Banerjee(2011), Agarwal and Chauhan (2014), Dey et al.(2012), Khandare and Rao(2006)].

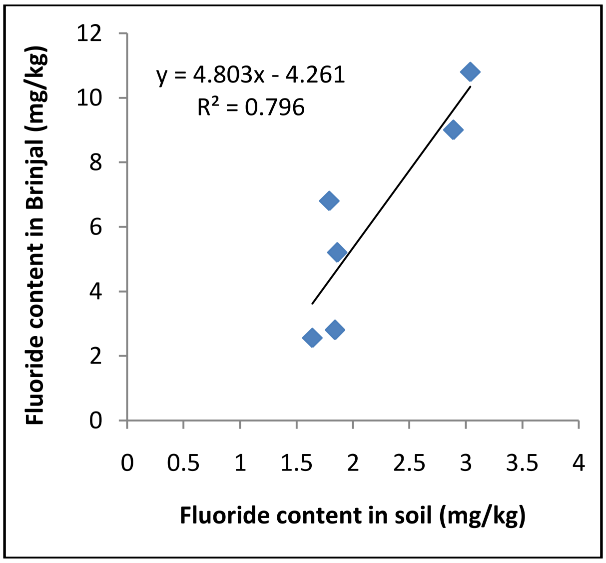
Fluoride concentration in ground water: From the analysis of ground water fluoride, it is found that the all ground water samples of three locations among the six shows fluoride concentration higher than the permissible limit i. e. 1.5ppm. Continuous use of such groundwater for irrigation may increase the soil fluoride content and thus increased uptake of fluoride by plants. But higher fluoride content is also recorded in some vegetable samples which are irrigated with low fluoride containing water. It may be dependent on the amount of water use in irrigation, number of irrigation practices done, plant's physicochemical nature to uptake water and water holding capacity of soil. In irrigated areas, the use of such ground water containing higher levels of fluoride is of the concern due to its consumption in plant matter following its plant uptake from irrigated soils (Scholz et al., 2015).

Bioconcentration factor (BCF): For estimating fluoride concentrations in vegetables, the common parameter is the Bioconcentration factor (BCF) which is used as an indicator of affinity for the accumulation of fluoride in plants (Mondal and Gupta, 2015). BCF is the ratio of fluoride concentration in the vegetable and fluoride concentration in soil, i.e.

$$\mathrm{BCF} = \frac{\text{Fluoride concentration in vegetable (mg/kg)}}{\text{Fluoride concentration in soil (mg/kg)}}$$

The higher BCF values (> 1) in three vegetable samples indicated that these plants have high affinity for the accumulation of fluoride. However, Swartjes et al., had reported that BCF values are not always constant in specific crops and vegetables and is largely affected by soil properties like soil pH, clay content, organic matter and fluoride concentration in soil and also plant factors like type of plant and growth rate. Here, all the samples of the selected vegetables from the six locations show BCF values higher than 1(table 1, 2, 3, 4 and 5), indicating their high affinity towards fluoride accumulation. Potato samples show highest BCF (average 3.64), whereas bean samples show lowest BCF (average 1.41).





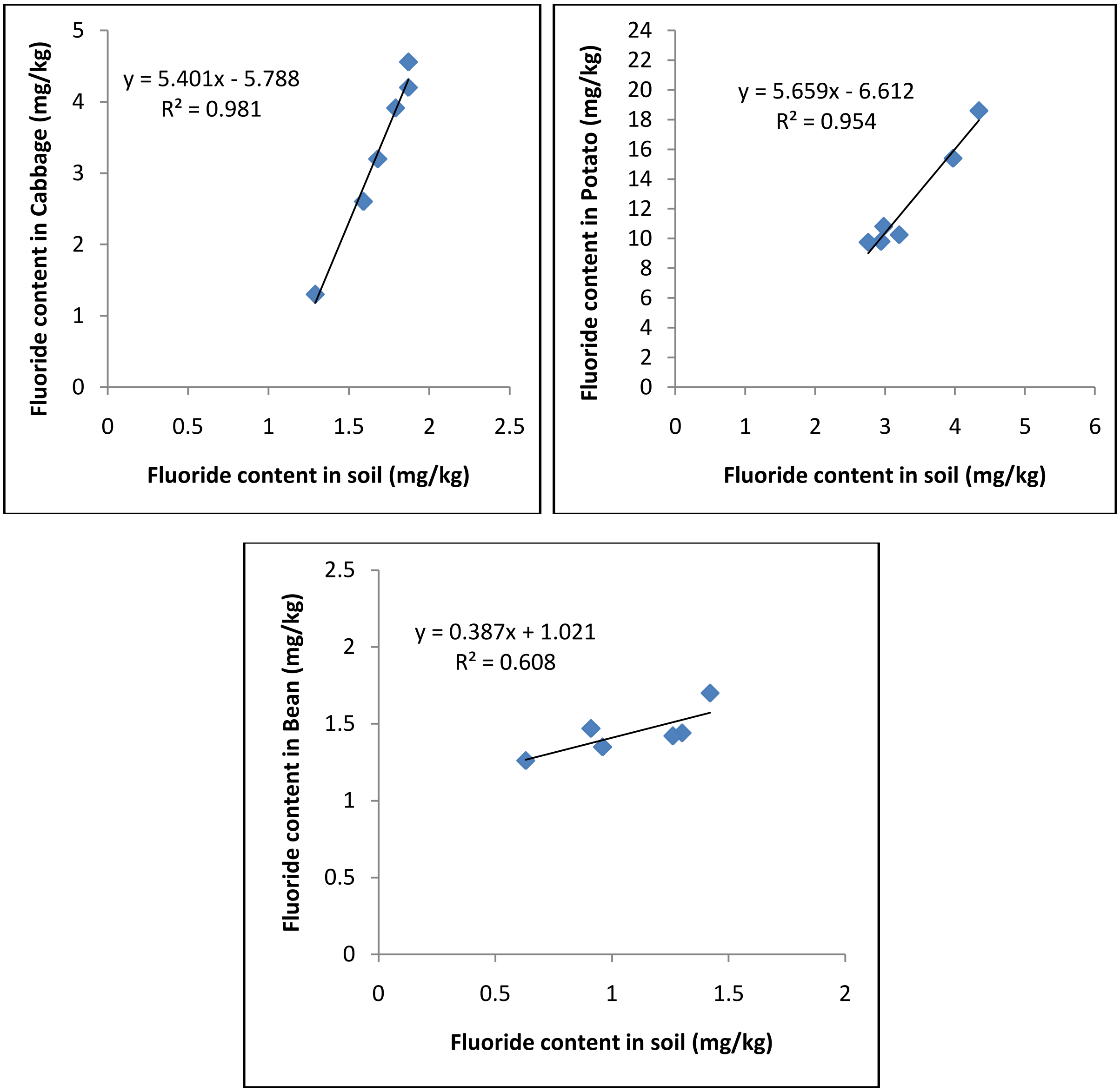


Figure 1: Relation between fluoride content in soil and fluoride content in different vegetables.

Table 1: Fluoride content in Tomato (*Solanum lycopersicum*), soil and irrigation water

SL No	Location	Fluoride Content in tomato(mg/kg)	Soluble Fluoride content in agricultural soil (mg/kg)	Fluoride content in irrigation water (mg/L)	BCF
1	North Guwahati	4	1.82	1.64	2.2
2	Sualkuchi	6.8	1.98	1.59	3.43
3	Kamalpur	2.6	1.53	1.04	1.7
4	Singimari	4.8	1.87	1.37	2.57
5	Hajo	6.4	1.91	1.78	3.35
6	Samaria	2.8	1.64	1.26	1.71
mean		4.6	1.79	1.45	2.49

Table 2: Fluoride content in Brinjal (*Solanum melongena*), soil and irrigation water

SL No	Location	Fluoride Content in Brinjal (mg/kg)	Soluble Fluoride content in agricultural soil (mg/kg)	Fluoride content in irrigation water (mg/L)	BCF
1	North Guwahati	9	2.89	1.9	3.11
2	Sualkuchi	2.8	1.84	1.56	1.52
3	Kamalpur	6.8	1.79	1.46	3.8
4	Singimari	10.8	3.04	1.5	3.55
5	Hajo	5.2	1.86	1.82	2.8

6	Samaria	2.56	1.64	1.23	1.56
mean		4.6	2.18	1.58	2.72

Table 3: Fluoride content in Cabbage (*Brassica oleracea capitata*), soil and irrigation water

SL No	Location	Fluoride Content in cabbage(mg/kg)	Soluble Fluoride content in agricultural soil (mg/kg)	Fluoride content in irrigation water (mg/L)	BCF
1	North Guwahati	4.56	1.87	1.86	2.44
2	Sualkuchi	3.2	1.68	1.6	1.90
3	Kamalpur	2.6	1.59	1.36	1.64
4	Singimari	1.3	1.29	1.2	1.01
5	Hajo	4.2	1.87	1.73	2.25
6	Samaria	3.91	1.79	1.43	2.18
mean		3.29			1.9

Table 4: Fluoride content in Potato (*Solanum tuberosum*), soil and irrigation water

SL No	Location	Fluoride Content in Potato (mg/kg)	Soluble Fluoride content in agricultural soil (mg/kg)	Fluoride content in irrigation water (mg/L)	BCF
1	North Guwahati	15.4	3.97	1.96	3.88
2	Sualkuchi	9.8	2.94	1.67	3.33
3	Kamalpur	9.75	2.76	1.47	3.53
4	Singimari	10.8	2.98	1.5	3.62
5	Hajo	18.6	4.34	1.89	4.29
6	Samaria	10.25	3.2	1.4	3.2
mean		12.43	3.37	1.65	3.64

Table 5: Fluoride content in French bean (*Phaseolus vulgaris*), soil and irrigation water

SL No	Location	Fluoride Content in French Bean (mg/kg)	Soluble Fluoride content in agricultural soil (mg/kg)	Fluoride content in irrigation water (mg/L)	BCF
1	North Guwahati	1.7	1.42	1.67	1.2
2	Sualkuchi	1.44	1.3	1.3	1.11
3	Kamalpur	1.47	0.91	0.54	1.62
4	Singimari	1.26	0.63	0.69	2
5	Hajo	1.42	1.26	1.52	1.13
6	Samaria	1.35	0.96	0.78	1.41
mean		1.44	1.08	1.08	1.41

ANOVA analysis: From the analysis of one way ANOVA, it is found that the p value is lower than the 0.05 (table 6). This indicates that there is a significant relationship between the mean fluorides concentrations of different vegetables collected from six different locations.

Table 6: One way ANOVA table

ANOVA

fluoride_content

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	424.391	4	106.098	18.086	.000
Within Groups	146.660	25	5.866		
Total	571.051	29			

IV. Conclusion

The present study indicated that vegetables are also a source of fluoride in human body. All the six agricultural areas of Kamrup district of Assam, India are dependent on groundwater for irrigation in winter season which lead to high fluoride concentration in soil and thus vegetables. All the vegetables have high affinity to accumulate fluoride available in the soil and irrigation water. To reduce the risk of fluoride exposure of human being, the use of fluoride contaminated irrigation water should be reduced and instead of ground water, surface water should be used for irrigation as the fluoride concentration in surface water is found generally lower than the ground water. In winter season due to scarcity of rainfall farmers mainly depends on ground water for irrigation. Even in this season, ground water fluoride concentration increases as the water table goes down to a considerable level. Normally all the selected five vegetables grown in winter season and therefore it is susceptible to accumulate more fluoride. Another reason may be the use of phosphate fertilizers in the agriculture as it is widely used in Kamrup district of Assam. Therefore importance should be given on the use of organic fertilizers instead of chemical fertilizers.

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