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In-Vivo uptake of fluoride by Pearl millet [*Pennisetum typhoideum* Rich.] irrigated with fluorinated groundwater

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Abstract — In Kheralu taluka of mehsana district, people have health risk due to the excess of fluoride in the drinking water and dietary materials. Irrigation of agricultural lands with high fluoride content has lead to rise in accumulation of fluoride in crops. The current research investigated fluoride content in groundwater and soils of the agricultural fields of kheralu region. Bioaccumulation of fluoride in P. typhoideum which is one of the major crops of the region was also determined along with its bioconcentration factor. The highest concentration of fluoride [13.6 mg/l] was found in the water sample from bore well of Malarpura. The fluoride content of rest 9 endemic villages ranged from 2.35 to 5.38 mg/l while the fluoride content in agricultural soils ranged from 30 µg/g to 342 µg/g. Fluoride accumulation in bajra was found to be in the range of 4 µg/g to 92 µg/g while its BCF ranged from 0.02 to 0.27

Keywords — Fluoride; Groundwater; Soil; Bajra; Kheralu;

I. Introduction

Fluorides possess considerable potential for causing ecological damage as they are not biodegradable and accumulate in the environment [1]. Elevated concentrations of fluoride in soil are proved to be toxic to plants [2] and thereby for animals and human beings [3]. Accumulation in vegetables, particularly in areas irrigated and non-irrigated soils with highly fluoride contaminated water may be a threat to human health [4]. In India, 17 of its 32 states have been identified as endemic fluorosis areas with an estimated 66 million people at risk and 6 million people seriously affected [5].

The element fluorine, a pale grenish yellow gas, condenses to liquid at 120˚c and frezes at minus 250˚c. |It is very active'and, because of its strong tendency to combine with other elments, rarely ocurs in puregaseous form. Fluoride ion is widespread in nature; it is estimated to be thirtenth in abundance among the elments of the earth, one of the 92 naturally occurring elements, is found in rocks, soil, freshwater, and ocean water. The major sources of high F^- in soils include weathering of fluorine-rich minerals in country rocks [6], as well as various anthropogenic sources. Fluoride is a common constituent in rocks and soils; its average concentration is 650 mg L-1 in the continental crust [9] and 300 mg L-1 in soils [8].

The Kheralu taluka of mehsana district people have health risk due to the excess of fluoride present in the drinking water and dietary materials. This block is rich in agricultural with the majopr crop being wheat [winter] and Bajra [Monsoon]. The block is highly dependent on groundwater, for both irrigation and drinking water purposes. During the last century, large scale utilization of groundwater for irrigation, so that groundwater source getting low rate. As a result, Kheralu taluka region face the problems like dissolution of Fluorides and other dissolved salts in drinking water. Irrigation of agricultural lands with high fluoride content has lead to rise in accumulation of fluoride in crops. The present work was based on the study to determine the accumulation of fluoride in crops of certain endemic fluoride villages.

II. Material and Method:

Study area:

The study area i.e. Kheralu Taluka is located at the north-eastern part of the Mehsana District in Gujarat state. It is located between 23.82N to 23.98N latitude and 72.48E to 72.79E longitude [Figure 1] covering an area of 334.24km with 114730 populations [2001 census]. The climatic condition of the study area is semi arid with temperature varying from 42°C to 20°C Rainfall is scanty about 350mm thus groundwater is the only source for both drinking and irrigation purpose. Commercial crops grown in the area are Bajra, Jowar, and Wheat etc.

Water, Soil and vegetation sampling:

Soil, water, and vegetation samples were collected from 20 different villages of Kheralu taluka, Mehsana district, Gujarat [Fig. 1]. A total of 80 water samples were collected from bore wells and were stored in polypropylene carboys bottles. Out of 20 villages the villages having fluoride above its permissible limits were selected for soil and vegetation study. 40 agricultural land soil samples from a depth of 0–45 cm were collected, mixed, and stored in plastic bags for further analysis and 40 vegetation samples of same location were collected, were sun dried and stored for further analysis.

Determination of Fluoride content in water:

Fluoride concentration in water samples collected from different villages of Kheralu taluka, Mehsana district, Gujarat, was determined using fluoride ion selective electrode [Orion 96-09 ion selective electrode]. Standard F−1 solutions [0.1–10 mg/l] were prepared from a stock solution [100 mg/l] of sodium fluoride. TISAB III was used for determination of fluoride

Determination of Fluoride content in soil and vegetation:

Determination of total fluoride content in soil and vegetation samples was estimated through NaOH fusion method [10]. This method involves fusion of soil and vegetation samples with 16 N NaOH in Ni crucibles 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. Then the samples were filtered and transferred to 100-ml volumetric flasks and diluted with double-distilled water to 100 ml. To the 45ml of the above extract, 5 ml of TISAB solution was added and mixed, and the F−1 measurement was estimated through was determined using fluoride ion selective electrode [Orion 96-09 ion selective electrode. The detection limit of method [LOD] was 0.01 mg/l.

III. Result and discussion

F^{-1} content in water samples

The Fluoride content of water measured showed following results. Out of 20 villages of Kheralu taluka, ten villages contain fluoride more than permissible limit which is 1.5 mg/l, three villages were on permissible limit while 7 below it. The variations of F−1 content in water from different villages are presented in Fig. 1. The lowest F−1 content was found in water sample of Amarpura [0.67 mg/l]. Whereas, the highest level of fluoride [13.6 mg/l] was found in the water sample obtained from bore well of Malarpura. The fluoride content of rest of 9 villages range within 2.35 to 5.38 mg/l. The 10 villages having fluoride concentration above 1.5 mg/l were chosen for further study.

Fluoride content in Soil and vegetation:

The fluoride content of the soil and Bajra grain cultivated on the soil are as shown in Fig 2. As shown in mean total F−1 content of 0–45 cm surface soil from the selected villages ranged from 30 µg/g to 342 µg/g while mean fluoride content of Bajra grain grown on the polluted soil varies from 4µg/g to 92µg/g. Highest Fluoride was observed in Bajra grown in Malarapura village having 342 µg/g fluoride in soil and irrigated with an average of 13 ppm fluoride and least fluoride was observed in panchha i.e. 4 µg/g grown in soil contaminated with 30 µg/g and irrigated with 3.71 ppm fluoride contaminated water.

Many previous works conducted by various workers showed similar results of accumulation of fluoride in grains grown and irrigated in contaminated land. Previous studies on Bajra showed similar results [11, 12, 13]. Patel and Bhatt [2008] showed accumulation in food crops grown in the North Gujarat of which result obtained for bajra were similar. Gautam et al [2010] showed similar results obtained from the agricultural crops in fields from Nava tehsil, Nagpur district. Saini and Khan [2014] showed much higher accumulation at the similar ppm of fluoride in irrigation water.

A good positive correlation is observed between soil fluoride and bajra fluoride. Also Excellent positive correlation is observed between water fluoride and Bajra fluoride [r = 0.93] indicating influence on accumulation by grain due to irrigating crops using contaminated groundwater.

The Bio-concentration factor [BCF] of the area ranges from 0.02 to 0.27 as shown in Fig 2. The highest BCF factor is seen in Chotiya i.e. 0.27 though the soil fluoride is 95 µg/g, the accumulated fluoride in Bajra grain is 26.3 µg/g. Similar result is seen in Gorisana where BCF is 0.23. Such difference of BCF can be due to difference in physico-chemical factors of soil. Also the use of fertilizer[14] can also effect the accumulation of fluoride in crops like use of phosphate fertilizer in case of Gathaman has increased the fluoride accumulation rate and thus the high BCF while the use of gypsum can be possible reason of reduced BCF and thereby lower accumulation of fluoride in grains.

The Plant showed no major toxicity in the crop. The toxicity level of fluoride on plant is a big debate as in some plants are so sensitive that <20 µg F/g dry biomass shows injury eg, Gladious while in some accumulation goes upto 4000 µg F/g dry biomass without any sign of injury[15].

While no symtoms of toxicity was observed on plants the people consuming contaminated food and water showed symptoms of dental and skeletal fluorosis. Bhargava and Bhardwaj showed fluoride is entering human food and beverages chain in increasing amount through the consumption of tea, wheat, cabbage, carrots and other Indian food. Various studies done in China suggested that contribution from food can significantly contribute to the total fluoride uptake [16, 17]. Bioaccumulation of fluoride in pearl millet creates third source of fluoride to human population resulting in food- borne fluorosis, primary source being water [18].

IV. Conclusion

Fluoride is getting accumulated in the grains of the bajra plant due to use of contaminated irrigation water and contaminated soil. The people consuming such contaminated grain are exposed to the fluoride which, are causing the fluorosis in the people. In absence of intake of nutritious diet the people are easily affected to high amount of fluoride from drinking water and the food.

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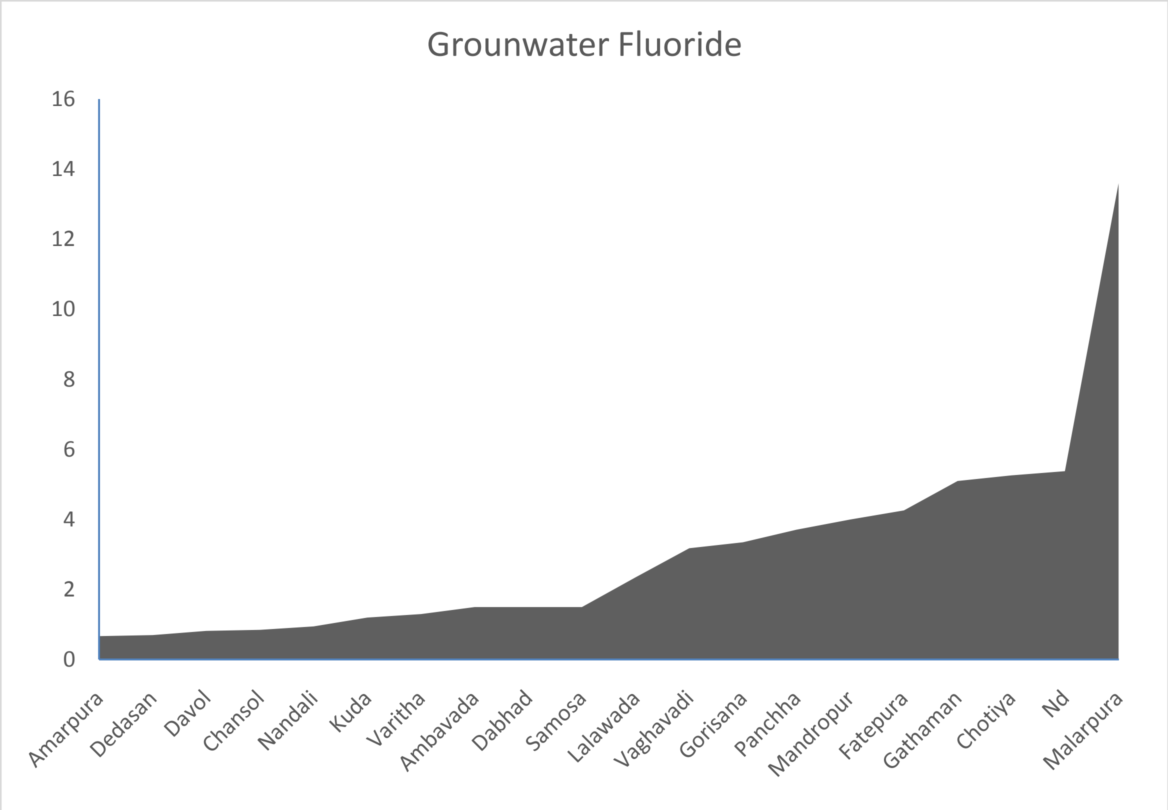

Figure 1

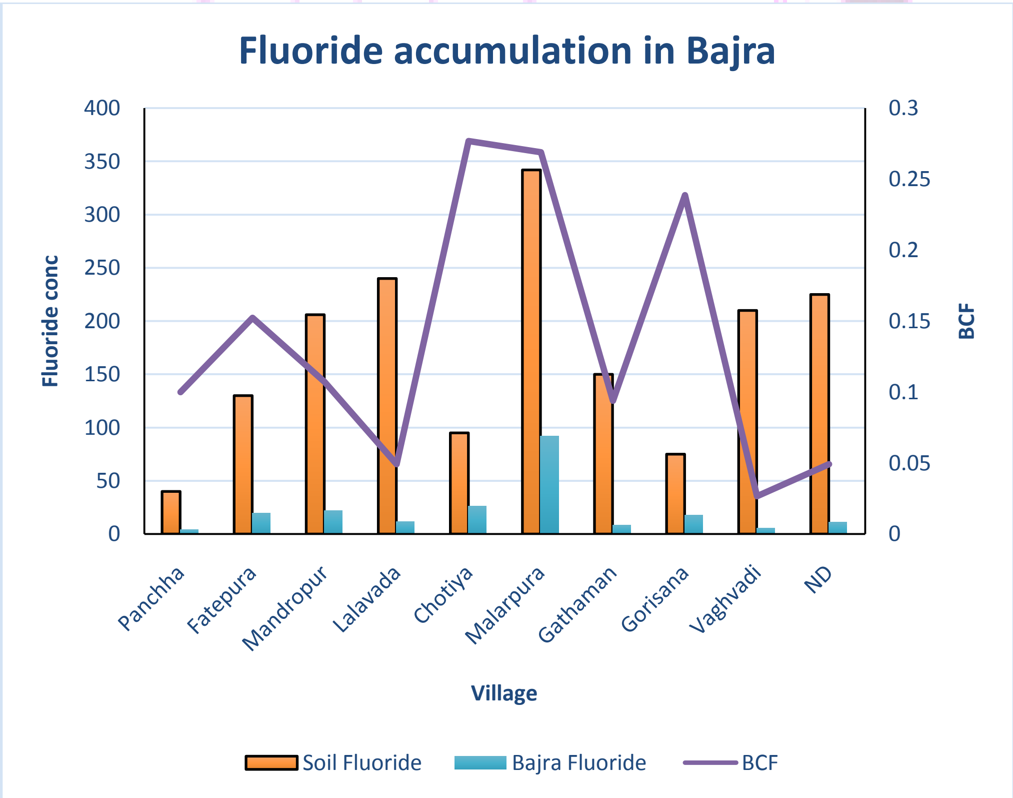

Figure 2