

Fluorides in the Groundwater of Punjab

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ABSTRACT

Out of total number of sample analyzed for fluoride, 43.5% had fluoride less than 0.5mg/l, which require fluoridation, 26.4% were in the desirable range, whereas 29.7% had fluoride in excess, which need defluoridation. Investigation on defluoridation indicated that flocculation with alum was effective, but the efficiency was alkalinity dependent. The adsorption approach for treating water supplies to remove fluoride is also considered effective. For fluoridation, addition of fluoride in the toothpaste and mouthwash paste has proved to be effective.

Key words: Ground water, fluorides, alkaline

INTRODUCTION

Throughout many parts of the world, high concentrations of fluoride occurring naturally in groundwater, in low concentrations they causes dental caries especially in children. If fluorides are present in excess of 1.5 mg/l, they may give rise to dental fluorosis. As concentration increases substantially, fluorosis can have serious effects on skeletal tissue as well, with adverse changes in bone structures (Fawell et al, 2006). Increased exposure of fluorine containing compounds lead to accumulation of fluorides in hard tissue of bone and teeth, which may result in numerous dental disorders (Blaszczyk et al., 2011). The investigation relates to the period from August 2010 to September 2011.

Fluoride exists fairly abundantly in the earth's crust and can enter groundwater by natural processes; the soil at the foot of mountains is particularly likely to be high in fluoride from the weathering and leaching of bedrock with a high fluoride content.

According to the World Health Organization (WHO), 1.1 billion people in low and middle-income countries lack access to safe water for drinking, personal hygiene and domestic use (WHO, Nov. 2004). In 1984 guidelines published by the World Health Organization fluoride is an effective agent for preventing dental caries if taken in 'optimal' amounts (WHO 1984). But a single 'optimal' level for daily intake cannot be agreed because the nutritional status of individuals, which varies greatly, influences the rate at which fluoride is absorbed by the body. A diet poor in calcium, for example, increases the body's retention of fluoride.

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Water is a major source of fluoride intake. The 1984 WHO guidelines suggested that in areas with a warm climate, the optimal fluoride concentration in drinking water should remain below 1ppm, while in cooler climates it could go up to 1.2ppm. The differentiation derives from the fact that we perspire more in hot weather and consequently drink more water. The guideline value (permissible upper limit) for fluoride in drinking water was set at 1.5ppm, considered a threshold where the benefit of resistance to tooth decay did not yet shade into a significant risk of dental fluorosis.

MATERIAL AND METHODS

For investigation of fluorides, samples were collected randomly from 21 districts of Punjab. The samples were collected in 250ml polyethylene bottles. The samples were immediately cooled to 4°C. The maximum storage limit is 7 days for Fluorides. For estimation of Fluorides, Ion Selective Electrode method was used.. Both the measuring techniques for Fluorides are given in Standard Method (AWWA, 1992). Both the Electrodes were for Orion. U.K. and before field work, the calibration curves were checked. Fluoride removal was done by the flocculation method commonly known as jar test. The technique involves the addition of precipitant/flocculant to the fluoride containing sample followed by precipitation/flocculation, sedimentation and possibly filtration at a desired time interval. The stirring time was 20 minutes at a speed of 55 rpm and the settling time 50-60 minutes.

Defluoridation of water: There are basically two approaches for treating water supplies to remove fluoride: flocculation and adsorption (Prevention and Control, 1993 and UNICEF).

Flocculation: The Nalgonda technique (named after the village in India where the method was pioneered) employs this principle. Alum (hydrate aluminium

salts), a coagulant commonly used for water treatment, is used to flocculate fluoride ions in the water. Since the process is best carried out under alkaline conditions, lime is added; bleaching powder can also be added to disinfect the water. After a thorough stirring, the chemical elements coagulate into flocs that are heavier than water and settle to the bottom of the container. The operation can be carried out on a large or small scale, and the technique is suitable for both community or household use. One household version uses a pair of 20-litre buckets, with a settling time of one hour and not more than two hours: after coagulation and settling are complete, the treated water is withdrawn through a tap 5 cm above the bottom of the first bucket, safely above the sludge level, and stored for the day's drinking in the second bucket.

Adsorption: The other approach is to filter water down through a column packed with a strong adsorbent, such as activated alumina (Al_2O_3), activated charcoal, or ion exchange resins. This method, too, is suitable for both community and household use. When the adsorbent becomes saturated with fluoride ions, the filter material has to be backwashed with a mild acid or alkali solution to clean and regenerate it. The effluent from backwashing is rich in accumulated fluoride and must therefore be disposed of carefully to avoid recontaminating nearby groundwater.

RESULTS AND DISCUSSIONS

It was investigated that there exist a salt range (fluorine) that runs obliquely across the Punjab through Kasur, Raiwind, Sangla Hill, Chiniot, Hundewala, Sargodha, Shahpur and to the eastern part of Mianwali which may be responsible for high fluoride concentrations in groundwaters.

For Fluoride, climatic conditions, volume of water consumed, and intake from other sources should be considered when setting an optimum F-value for Punjab.

As the Punjab Province is situated mainly in the Indus plain, air temperatures in the summer are high. They contribute to a high annual average of maximum daily air temperatures ranging from 31.7°C to 37.8°C (Kureshi, 1988).

Results of fluoride determinations shows that numerous cases are below and above the desirable limits of fluorides. The district wise fluoride range is given in Table 1. High values have been obtained from Lahore, Raiwind, Kasur, Sheikhpura, Rahim Yar Khan, Bahawalnagar, Sahiwal, Jhang, Gujranwala and Sargodha Districts. Results were also statistically analyzed. Table-2 shows that out of the total samples analyzed, 42.5% of the hand-pump

samples had fluoride content less than 1.5 mg/l with chances of dental caries to occur. Fluoride content of 23.11% of samples was found in the desirable range and 34.39% of the samples had a fluoride content in excess, which means existence of potential dangers of dental fluorosis.

Maximum value was obtained from Lahore district, where the value ranged from 0.15 to 23.60 mg/l. The higher values were from the town of Raiwind (Manga Mandi). The second highest range of 0.37 - 6.40 mg/l was obtained from the city of Kasur. The fluoride content in the drinking water between of both Raiwind and Kasur (Fig.1).

The higher value of 23.6 mg/l was obtained from an Abandon well at Raiwind. Its water is not being used for drinking purposes.

Marshall Day (K. Ahmed, 1981), analyzed a number of samples from this town in 1940, the value of fluoride ranged from 1.2 to 6.4 mg/l. He also mentioned about people suffering from acute dental fluorosis. Samples collected from villages south of this town showed similar results. Raiwind was not mentioned in the Marshall Days report.

Information obtained from local health authorities and Dental surgeons showed that mottling of teeth is common in the town of Raiwind, Manga Mandi and its adjoining areas. It was also found that about 124 children have been suffered from chronic intake of excessive fluoride and permanent bone and joint deformation of skeleton fluorosis (Ahmed M, 2003).

Fluoride removal: Experiments were carried out with calcium chlorides, aluminum sulphate and calcium chloride, alum and calcium hydroxide and alum alone. Experiment conducted with alum and $CaCl_2$, with 114 mg/l Ca^{++} and 200-mg/l alum, F removal was less effective. Further experiments were carried out with alum alone. With a dose of 250 mg/l F were reduced from 5.5 mg/l to 0.46 mg/l.

So far all test waters had the same alkalinity (70 mg/l as $CaCO_3$). In the next experiment the alkalinity was raised through the addition of $NaHCO_3$ to 230 mg/l as $CaCO_3$. With initial fluoride concentration of 11.9 mg/l in the test water a dose of 400 mg/l alum reduced the fluorides to 3.5 mg/l only. Results are shown in Table-3.

Fluoridation: Ingestion of fluorides at the optimum levels is effective in reducing dental caries and is not in any way harmful (Maler, F.J, 1988). Many people who are convinced of these conclusions however, believe that some means other than the water supply should be used for providing the fluorides. If such other means could be found, then only that portion of the population which would be primarily benefited would receive it. The following alternatives are

commonly used in both developed and developing countries.

Tooth paste, mouthwash and chewing gum: Toothpaste containing stannous fluoride has been quite effective. Care must be exercised in using it because of possible excessive fluoride intake, particularly among children who might consume it for its candy like flavor. Fluoride is known to reduce enamel solubility during the caries process (Haghes J. A, 2004).

Bottled water: The use of bottled fluoridated water is probably the best substitute for a fluoridated public supply. It is least harmful and least expensive.

Fluoride Containing Tablets: Tablets containing specific amount of fluoride (0.1 mg) have been used in two ways - taken daily as a pill or dissolved in the children's drinking water (Bottenberg, P 2011). At present, no results have been published showing conclusively that this method is effective.

Table-1: Statistical summary of Fluoride Concentration in the Drinking waters of Punjab (Period 1997 – 1999)

District	Sample Exam. No.	Mean	Minimum	Median	Maximum	S.D.
Attock	5.0	0.46	0.18	0.56	0.65	16.0
Bahawalpur	6.0	0.63	0.29	0.78	0.98	50.0
Bahawalnagar	6.0	1.67	0.24	0.23	2.50	9.0
Dera Ghazi Khan	4.0	0.54	0.19	0.69	0.80	10.0
Faisalabad	10	1.54	1.00	1.48	1.90	7.0
Gujrat	5.0	0.59	0.46	0.51	0.60	39.0
Gujranwala	16	1.58	0.22	1.04	1.90	6.0
Jhelum	7.0	0.44	0.10	0.52	0.75	14.0
Jhang	12	1.50	0.23	1.09	1.60	42.0
Kasur	12	4.38	0.37	5.49	6.60	96.0
Lahore	28	12.96	0.15	16.9	23.60*	92.0
Mianwali	12	1.00	0.30	1.04	1.50	18.0
Multan	8.0	0.39	0.16	0.44	0.65	32.0
Muzaffargarh	7.0	0.32	0.15	0.39	0.58	17.0
Rawalpindi	9.0	0.30	0.16	0.21	0.38	56.0
Rahim YarKhan	6.0	2.00	0.50	0.79	2.00	7.0
Sargodha	20	1.62	0.18	2.00	2.80	6.0
Sialkot	8.0	0.40	0.23	0.38	0.54	19.0
Sheikhupura	13	3.58	0.27	4.92	5.80	25.0
Sahiwal	12	1.62	0.24	1.98	2.40	8.0
Vehari	6	0.96	0.22	1.00	1.50	92.0

• Value is from an abandoned well at Raiwind Town

Table 2: Statistical analysis of Samples Analyzed for Fluorides

Source	No. of Samples Analyzed	%age of Samples Falling in the Fluoride Content Range of			Total
		- 0.4mg/l	1.5mg/l	>1.5mg/l	
Hand Pumps	157	42.50	23.11	34.39	100
Tube-wells	35	71.43	15.86	12.71	100
Open Wells	20	40.50	25.25	34.25	100

Table 3: Removal of Fluorides using alum (Treated Water Alk – 230 mg/l)

Alum m/l	Added mg/l	Stirring time min.	Settling Time min.	PH –	Fluorides mg/l
0	0	–	–	7.5	11.0
1	100	20	50	6.9	7.4
2	150	20	50	6.8	6.5
3	200	20	50	6.5	6.0
4	250	20	50	6.8	5.2
5	300	20	50	6.7	4.8
6	350	20	50	6.5	5.2
7	400	20	50	6.2	3.5

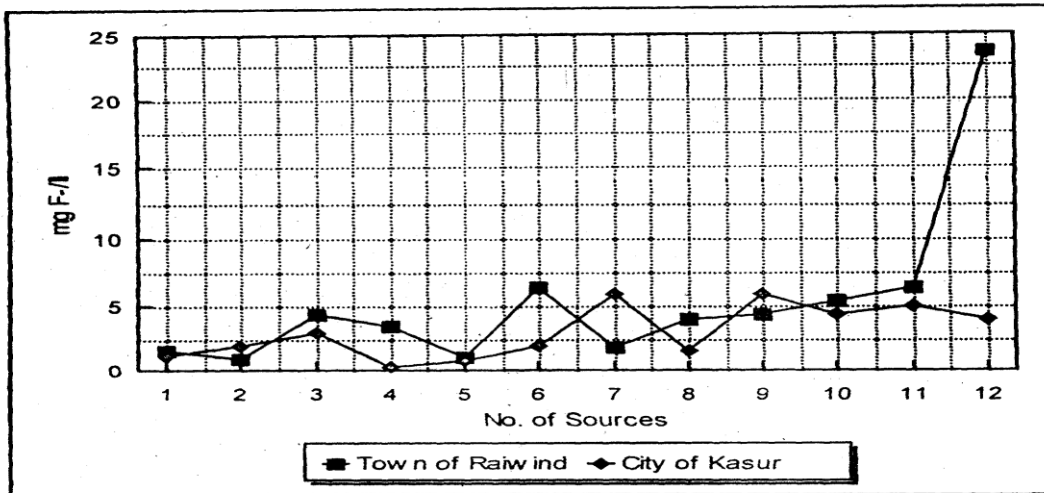


Fig.1: Concentration of fluorides in the Town of Raiwind and Kasur city. Sample Nos. 3, 4, 6, 10 and 12 are shallow well from Raiwind town. Well No. 12 is not used for drinking water

CONCLUSIONS

1. The salt range which passes from Kasur in the east to Mianwali in the northwest of Punjab is responsible for high fluoride concentrations in some drinking waters. 212 samples of groundwater source were analyzed from 21 districts of Punjab for Fluoride concentration.
2. Maximum samples were collected from hand pumps. 42.5% of the samples had F⁻ content less than the desired limit with chances of dental carries to occur. 34.39% of the samples had excess F⁻ which means existence of potential dangers of dental fluorosis.
3. Higher values of F⁻ were observed from the town of Raiwind and city of Kasur.
4. The maximum value of 23.6 mg/l was obtained from an abandoned well at Raiwind.
5. Cases of mottled enamel were noted in Raiwind, Kasur, Sangla Hill, Shahkot, Mianwali and 163 children of bone disorder in Manga Mandi.
6. Experiments on the removal of excessive fluoride showed that flocculation with alum was effective in jar tests, but the efficiency depends on the alkalinity of the water. Low alkalinity is essential to achieve desirable results.
7. Alternatives for fluoridation include addition of fluorides in toothpaste, mouthwash/chewing gum.

RECOMMENDATIONS

1. More detailed study should be carried out to find out the waters which need fluoridation and those which need defluoridation.
2. A health survey of the country should be carried out in detail to investigate the cases of endemic

fluorosis so that preventive measures can be taken easily and expeditiously.

3. Good quality water should be supplied for human use in the areas having high fluoride content.
4. An action should be initiated to carry out fluoridation and defluoridation of those waters whose fluoride concentration is now known to be out of specified range.

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