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A DETAIL STUDY ON DRINKING WATER QUALITY AND DENTAL FLUOROSIS IN MELUR

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In this study, groundwater quality with reference to fluoride and other chemical parameters such as pH, total alkalinity, hardness, calcium and salinity was tested in samples collected from Melur, a dental fluorosis prone area. Nineteen water samples from various sources *viz.* well, bore well and hand pump collected in different sites of the study area were examined. The study reveals that all the parameters except salinity are within standard limits in municipal water. Six ground water samples were found to have high fluoride levels above the Indian standard for potable water (1.0 mg/l). The study shows that elevated fluoride level is associated with lowering of hardness and calcium levels in water. The present investigation suggests that people of Melur should be advised to consume only municipal water. Ground water can be used for potable purpose only after its treatment for fluoride. Awareness on the consequences of excessive fluoride intake and its preventive strategies must be given.

Key words : Groundwater, fluorosis, hardness.

INTRODUCTION

Water is an essential natural resource for sustaining life and environment that we have always thought to be available in abundance and free gift of nature. However, chemical composition of surface or subsurface is one of the prime factors on which the suitability of water for domestic, industrial or agricultural purpose depends. Freshwater occurs as surface water and ground water. Though ground water contributes only 0.6% of the total water resources on earth, it is the major and preferred source of drinking water in rural as well as urban areas.

In a country like India, where the majority of population lives in the villages with bare infrastructural facilities, lack of awareness, poor hygiene and sanitation, the concept safe potable water assumes greater significance. It is estimated that only 77% of urban population and 31% of rural population in India are able to get potable water supply (Gupta *et al.*, 2002).

Ground water forms a major source of drinking water supply for urban and rural population of India due to non availability of other water resources and the consideration that surface soil strata acts as a natural filter providing safe and pure drinking water. However, various studies carried out in the previous years have clearly shown that ground water is also becoming highly susceptible to pollution from diffuse sources like deep percolation from intensively cultivated fields. The major sources of high fluoride in water are anthropogenic activities and leaching of soil (Sharma *et al.*, 2002). The problem of high concentration of fluoride in underground water sources and the resultant disease 'Fluorosis' has been emerging as one of the most important toxicological and geo-environmental issues throughout the world. But this problem is very serious in India as

the majority of the population living in rural areas has to depend on groundwater sources for their water requirements.

MATERIALS AND METHODS

Study Area : Melur is a town and municipality in Madurai district. It is located at 10.05° N 78.33° E. It has an average elevation of 149 meters. It has a population of 33,743.

Identification of fluoride endemic areas : A door to door survey was conducted among people in the areas of study to determine the prevalence of dental fluorosis. Drinking water samples from all available sources of the study area were collected.

Sampling strategy : Nineteen drinking water samples from different sites in Melur were collected in pre-cleaned polythene bottles of 500 ml capacity. The water samples collected included hand pump water, bore well water, well water and municipal drinking water. Alkalinity of the samples was tested at the site itself. Other chemical parameters were analysed after transporting the samples to the laboratory.

Chemical analysis of water : The sample collected from different locations in Melur were analysed for selected chemical parameters adopting standard methods (APHA, 1995).

RESULTS

Table I depicts the nineteen sampling sites in Melur and their codes .The estimated pH, phenolphthalein alkalinity, total alkalinity, hardness, calcium content, salinity and fluoride concentration of the nineteen water samples analyzed are given in Table II and the mean values of each parameter are shown in Table III

pH values of all the water samples examined varied from 6.77 to 8.15. A mean pH of 7.49 was obtained for all the water samples tested.

Total alkalinity of the water samples was found to vary from 200 to 670 mg/l .Sample no. 5 shows high alkalinity (670 mg/l). Six water samples (sample no. 1, 3, 5, 6, 10 and 18) showed phenolphthalein alkalinity in the range of 10-30 mg/l. In the remaining water samples, no phenolphthalein alkalinity was observed. Hardness of the water samples ranged from 224 to 1184 mg/l. Twelve water samples (samples no.1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 14 and 17) showed hardness above 600 mg/l and two (sample no.18 and 19) showed a value less than 300 mg/l. In the remaining five water samples (sample no. 2, 6, 13, 15 and 16) hardness was found to be within the standard limits. A mean total alkalinity of 445.26 mg/l was obtained for the nineteen water samples examined.

Calcium content of the water samples varied from 29.66 to 150.70 mg/l. Lower levels of calcium(less than 75 mg/l) was found in twelve samples (sample no. 2, 3, 4, 5, 6, 7, 9, 10, 13, 15, 18 and 19).In the other water samples calcium was found to be within standard limits. The mean calcium content of water samples was 70.33 mg/l. Salinity ranging from 0.73 to 10.34 ppt (mean = 5.31 ppt) was noticed in the water samples examined .

Fig. 1 shows the OD values of standard fluoride solutions used for the estimation of fluoride from water samples. Fluoride concentration in the water samples tested ranged from 0.2 to 1.8 mg/l. six water samples had fluoride content above 1.0 mg/l. They include sample no. 5 (1.6 mg/l), sample no. 6 (1.7 mg/l), sample no. 10 (1.4 mg/l), sample no.13 (1.8 mg/l), sample no 15 (1.5 mg/l), sample no .19 (1.7 mg/l). The mean fluoride level was 0.94 mg/l.

Results of correlation analysis between fluoride concentration and other chemical parameters examined are given in Table IV. Correlation coefficients (r) between fluoride concentration and pH, alkalinity, hardness, calcium and salinity were found to be -0.02, 0.7, -0. 4, -0.5 and -0.03, respectively.

Table I : Different sites of sample collection from Melur.

Sample Code	Water source	Depth in feet	Place
1.	Bore well	150	Nondikovil patty
2.	Municipal drinking water	-	Athukarai patty
3.	Bore well	250	Vinopacolony
4.	Panchayat union hand pump	150	S.Muthuvel patty
5.	Samuthaya well	75	Othapatty
6.	Tank (water from samuthaya well)	33	Sundarasapuram
7.	Panchayat union hand pump	150	Ettumangalam
8.	Panchayat union hand pump	150	Palayasukkam patty
9.	Bore well	250	Pottiyasukkam patty
10.	Well	32	Pallavirayan patty
11.	Private hand pump	155	Chokka patty
12.	Panchayat union borewell	260	Malampatty
13.	Panchayat union hand pump	150	Puttu patty
14.	Panchayat union hand pump	160	Attukulam
15.	Panchayat union hand pump	150	Vannam parai patty
16.	Panchayat union hand pump	150	Bustand
17.	Panchayat union hand pump	150	Vellanatham patty
18.	Bore well	150	Annacolony
19.	Hand pump	150	Sothinagar

DISCUSSION

People often think of water as a matter of taste, clarity and odour and in terms of other properties which determine weather water is fit for drinking. For other uses different properties may be important. Most of these properties depend on the kinds of substances that are dissolved or suspended in the water. Water quality should always be taken in relation to the purpose for which the water is used because water suitable for one purpose may not be suitable for the other. For example, the water that we drink can be used for irrigation, but water used for irrigation may not be suitable for drinking.

Table II : Chemical characters of water samples collected from Melur.

Sample No.	pH	PA $CaCO_3$/l	TA as $CaCO_3$ mg/l	Hardness as CaC mg/l	Ca mg/l	Salinity	Fluoride mg/l
1.	7.90	30	420	800	84.97	7.03	0.5
2.	7.75	-	380	350	61.72	0.73	0.3
3.	7.92	20	470	940	37.67	4.92	0.6
4.	7.58	-	540	720	49.70	4.92	1.0
5.	7.77	10	670	720	29.66	7.53	1.6
6.	7.94	10	390	520	36.87	3.53	1.7
7.	6.77	-	560	650	72.14	3.03	0.7
8.	7.17	-	490	756	88.18	6.92	0.7
9.	7.35	-	410	930	63.33	7.23	1.0
10.	8.15	20	510	1000	69.74	10.34	1.4
11.	7.28	-	420	664	88.18	6.02	0.2
12.	7.83	-	250	630	117.83	4.63	0.2
13.	7.42	-	410	300	32.06	1.64	1.8
14.	7.11	-	390	890	141.88	6.35	0.8
15.	7.08	-	520	590	33.67	6.92	1.5
16.	7.15	-	460	530	82.56	5.43	0.8
17.	6.85	-	600	1184	150.70	10.03	0.8
18.	8.11	20	370	224	34.47	1.02	0.5
19.	7.18	-	200	284	60.92	1.02	1.7

TableIII : Mean value of Chemical Parameters of water samples collected from Melur.

S. No.	Chemical parameter	Mean Value
1.	PH	7.49
2.	Total alkalinity as CaCO3 (mg/l)	445.26
3.	Total Hardness as CaCO3 (mg/1)	667.47
4.	Calcium (as Ca) mg/1)	70.33
5.	Salinity (ppt)	5.31
6.	Fluoride (mg/1)	0.94

Table IV : Results of correlation analysis between fluoride and other Chemical Parameters.

S. No.	Chemical parameters	Mean values
1.	PH	-0.02
2.	Total alkalinity as CaCO3 (mg/l)	+0.07
3.	Hardness as CaCO3 (mg/1)	-0.04
4.	Calcium (as Ca) mg/1)	-0.5
5.	Salinity (ppt)	-0.03

Pure water is tasteless and odourless. A molecule of water contains only one hydrogen and oxygen atoms. However, water is never found in a pure state in nature. Both groundwater and surface water may contain many constituents, including micro organisms, gases, inorganic and organic materials. Water quality is assessed by measuring the amounts of various constituents contain in the water. These amounts are

Table V : O.D. values of different concentrations of standard fluoride solutions used to plot standard graph.

Concentration of standard fluoride solution (mg/l)	O.D.
0.2	0.692
0.4	0.643
0.6	0.614
0.8	0.574
1.0	0.532
1.2	0.493
1.4	0.466
1.6	0.402
1.8	0.369
2.0	0.341

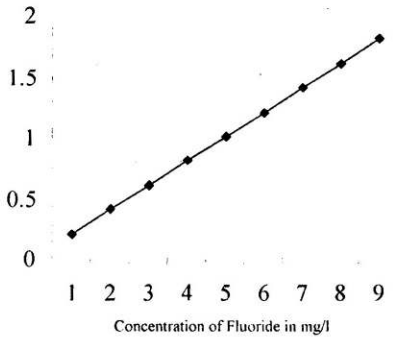

Fig. 1 : Standard graph for fluoride.

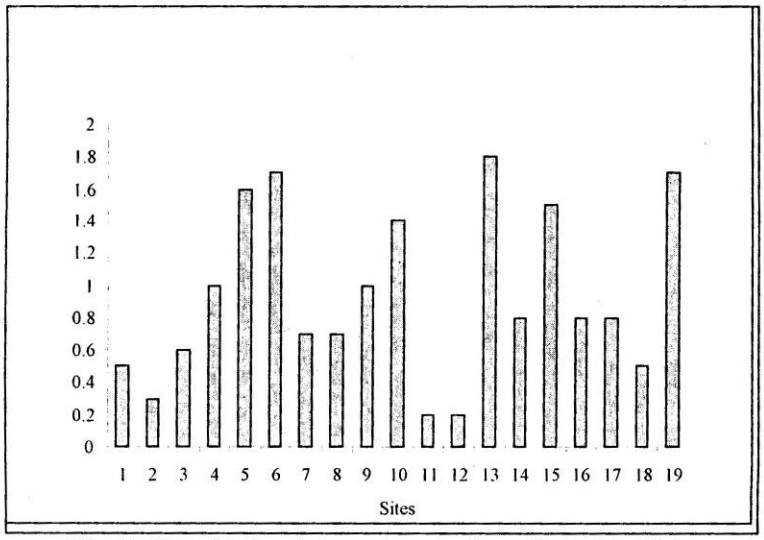

Fig. 2 : Fluoride levels in water samples collected in Melur.

often expressed as milligrams per litre (mg/l), which is equivalent to the number of grams of a substance per million grams of water. The suitability of water for a given use depends on many factors such as hardness, salinity and pH. Acceptable values for each of these parameters for any given use depend on use, not on the source of the water Drinking water is regulated by guidelines stringent enough to protect human health. In the present study, quality of ground water and municipal water in Melur was tested and reported by drinking water quality guideline (Bureau of Indian Standards,1991). Nineteen water samples collected at different locality in Melur were analyzed for Fluoride and other chemical parameters like pH, alkalinity, hardness, calcium and salinity.

pH

High pH and alkalinity of drinking water are not harmful to human beings. However, a low value of pH below 4.0 produces a sour taste and higher values of pH and alkalinity hastent the scale formation in pipes and water heating apparatus and also reduce the germicidal potential of chlorine. pH below 6.5 starts in corrosion in pipes . pH and alkalinity are also important in fixing alum dose in drinking water treatment (Trivedy & Goel, 1984).

While Sharma *et al.* (2002) reported a pH of 7.0 - 8.5 in the ground water of Unnao in Uttar Pradesh , Mariappan & Vasudevan (2002) found a pH ranging from 7.91 - 9.10 in the ground water of dental fluorosis - affected Panamarathupatty block of Salem district in Tamil nadu. Santhi *et al.* (2002) reported a pH of 7.34 - 8.88 in the ground water of fluorotic areas and 7.70 to 8.49 in control areas of Vallioor union of Thirunelveli district in Tamilnadu. Saxena & Shravastava (2002) studied ground water quality in Bhopal and found a pH of 6.2 - 8.5. In our studies, the pH values obtained (6.77 - 8.15) are in general agreement with the above discussed literature for pH. Also, the pH values obtained are well within acceptable limit (BIS, 1991).

Total alkalinity

Alkalinity in itself is not harmful to human beings (Pande & Sharma, 1999). Alkalinity is basically the dissolved minerals in water that help to neutralize the water. Sometime it is favourable to have high values of alkalinity because it enhances the buffering capacity of water. Alkalinity ranges of 115 - 500 mg/l, 150 - 200 mg/l and 390 - 660 mg/l were obtained in the groundwater of Armori town in Maharashtra (Patil *et al.*, 2001), drinking water of Thittagudi in Tamilnadu (Rani *et al.*, 2002) and Kadathur canal water of Amaravathi river in Tamilnadu (Karthikeyani *et al.*, 2002), respectively. These values when compared with the total alkalinity values obtained in the present investigation are almost similar .

In the present study, thirteen water samples (sample no 2, 4, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17 and 19) showed zero phenolphthalein alkalinity indicating the absence of carbonates in them. Thus, their alkalinity was mainly due to bicarbonates. In the rest of the six water samples, both carbonates and bicarbonates contributed to their alkalinity. The alkalinity of the water sample was within permissible limit except one (sample no 5), which showed an alkalinity value above 600mg/l. This was accompanied with increased fluoride concentration (1.6 mg/l in sample no 5).Values of alkalinity were lesser than hardness in sixteen samples(sample no 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, and

19). This suggests that in these samples ,neutral salts of calcium and magnesium may be present as sulphate (Rani *et al.*, 2002). In the remaining three samples (sample no 2, 13, and 18) alkalinity was found to be greater than hardness and may be due the presence of basic salts of sodium and potassium in addition to calcium and magnesium (Manivasakam, 1984).

Hardness

Hardness has no adverse effects on health. But it is undesirable due to the formation of heat retarding insulating scales in boilers and other exchange equipments. Hard water is not suitable for domestic use in washing, cleaning and laundering as it prevents the lather formation with detergents. Literature pertaining to the hardness of the water reveals an array of values such as 106 - 494 mg/l in the groundwater of Unnao in Uttar Pradesh (Sharma *et al.*, 2002), 120 - 447 mg/l in the Kadathur canal water of Amaravathi river in Tamil nadu (Karthikeyani *et al.*, 2002).In the present study , a much higher range of hardness was obtained (224-1184) It is noteworthy that two water samples (sample no. 18 and 19) showed hardness less than 300 mg/l and among these two, one sample (sample no.19) showed an elevated fluoride concentration of 1.7 mg/l.

Calcium

Calcium is one of the important nutrients required by the organism. It plays a major role in imparting hardness to water as calcium carbonate. High levels of calcium in natural waters are rare (Trivedy & Goel, 1984). In present observation the calcium range in water samples (29.66 - 150.70 mg/l) was different when compared to 40.72 - 126.99 mg/l in the groundwater of Chitrakoot in Satna (Tripathi *et al.*, 1996), 84.24 - 88.00 mg/l in Gadchiroli lake of Maharashtra (Patil & Tijarae, 2001) and 24.05 - 119.44 mg/l in the drinking water of Thittakudi in Tamilnadu (Rani *et al.*, 2002).

Calcium content lower than 75 mg/l was noticed in twelve water samples (sample no. 2, 3, 4, 5, 6, 7, 9, 10. 13, 15, 18 and 19) in the present investigation and out of these, six water samples (sample no. 5, 6, 10, 13, 15 and 19) showed increased fluoride concentration (above 1.0 mg/l). This shows that calcium content decreases with increase in fluoride concentration in water. The remaining seven water samples (sample no. 1, 8, 11, 12, 14, 16 and 17) showed calcium level less than the maximum permissible limit of 200 mg/l (BIS, 1991) and were associated with fluoride concentration less than 1.0 mg/l.

Salinity

Salinity is the amount of dissolved salt found in 1 kg of water. Salinity or salt content is expressed in parts per thousand (ppt) because there are 1000 gms in 1 kg. The average salinity of sea water is 35 ppt. Fresh water salinity is usually less than 0.5 ppt. Drinking water has to have salinity less than 0.2 ppt.

Santhi *et al.* (2002) reported a salinity range of 0.49 -1.49 ppt in the groundwater of Vallioor union of Thirunelveli district in Tamilnadu. Rani *et al.* (2002) found 0.12 - 0.58 ppt salinity in the drinking water of Thittakudi in Tamilnadu. In the present investigation, the salinity range was contrasting and very high also (0.73 -10.34 ppt). From the salinity values it is clear that all the water samples including municipal water contained high amounts of salts. High salinity may be responsible for scale formation in the water stored

vessels.

Fluoride

Fluoride is one of the important factors in water quality management due to its adverse health effects (Nemade, 1996). The effects of extensive intake of fluoride range from bone stiffness and rheumatism to permanent crippling and kidney damage (Odonnel, 1973; Waldbott, 1973). Dental fluorosis is most common occurring due to the presence of excess fluoride in public water supply (Elevove, 1940). Fluoride concentration in groundwater in India varies considerably. In some parts the fluoride levels were below 0.5 mg/l while at certain other places values as high as 20.0 mg/l were reported (Sarma, 1999). Santhi *et al.* (2002) found 2.39 - 5.66 mg/l and 0.74 - 1.20 mg/l fluoride in groundwater of fluorotic and control areas respectively in the Vallioor union of Thirunelveli district in Tamilnadu. Latha *et al.* (1999) reported groundwater fluoride concentration of 1.0-7.4 mg/l in Karnataka. In the present investigation, fluoride range obtained (0.2-1.8 mg/l) is not very high when compared with the above ranges. Only 31% (6 out of 19) of the water samples analysed, showed elevated levels of fluoride (sample no. 5, 6, 10, 13, 15 and 19). Most of the people residing in the localities where the samples were collected showed signs of dental fluorosis. Groundwater from the sources considered in the present study was being used for drinking purposes a few years ago.

Most of the people in the study area are drinking municipal water nowadays which has fluoride content (0.3 mg/l) and other chemical parameters within normal limits. Though not for drinking purpose, the bore well and hand pump waters are being used for cooking and washing vegetables by many residents of Melur and it is to be pointed out here that fluorides in water are not destroyed by heating or boiling.

Correlation analysis

The correlation of fluoride concentration with total alkalinity, hardness and calcium content in water samples is significant. Results of correlation analysis were in accordance with the report given by Teotaia & Mandsingh (1981) that when fluoride level in water is high, the water will be highly alkaline and become softer.

Swain *et al.* (2002) found a positive relationship between pH and fluoride concentration in water. But in the present study a negligible or very negative less relationship was obtained between pH and fluoride content ($r = -0.02$).

Gupta (1991) found that fluoride content increased with decrease in salinity. However, in our study very less negative correlation ($r = -0.03$) was obtained between salinity and fluoride concentration indicating negligible relationship between salinity and fluoride concentration.

The chemical analysis of the water samples collected in Melur reveals that the distribution of fluoride, pH, total alkalinity, hardness, calcium and salinity are not even in the groundwater in the study area. The people of this area have been exposed to high fluoride from some source since many years and hence, the prevalence of dental fluorosis in the area. Municipal water is safe for drinking with reference to fluoride and other chemical parameters studied. The six water samples which showed high fluoride contents (above 1.0 mg/l) suggested that groundwater may be the source for fluoride exposure to

the residents of Melur and such water is not advisable to be used for drinking and cooking purposes. Awareness about consequences of high fluoride in water and preventive strategies of dental fluorosis should be given to the people of Melur. They should be advised to use municipal water for potable purpose. During water scarcity, groundwater can be used for drinking and cooking only after suitable physical, chemical or biological treatment for fluoride. The urgent attention of the government is required to improve groundwater quality.

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