

# Ground water quality measurement: Analysing , Mapping, of fluoride exposure at South Tamilnadu

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## ABSTRACT

One of the major public issue in the environment is the contaminant in the ground water due natural and anthropogenic activities. Excess fluoride ion in drinking water lies one among the contaminant in ground water . Any water source having fluoride concentration above permissible limit 1.5 mg/L (WHO standards) requires treatment before usage. When the fluoride ion in drinking water is above the permissible limit it causes dental fluorosis and then skeletal fluorosis. In this study fluoride and other water quality parameters like pH, TDS, Alkalinity, Conductivity ,Total Hardness, Chloride, Sulphate were analyzed for 400 number of ground water samples taken from thiruchendur, Udangudi, Thoothukudi, Radhapuram blocks where the people depend on groundwater for domestic purpose located. After analyzing fluoride ion concentration, Exposure dosage, Correlation coefficient of different age groups mapping of fluoride concentration was done using Arc GIS. The water quality for most of the villages in four blocks are unfit for drinking purpose due to high TDS, Total Hardness, alkalinity, chloride . The fluoride concentration in ground water of four blocks ranges from zero to 5.6 mg/L. Four villages in thiruchendur block and six villages of udangudi block has fluoride level greater than the permissible limit. The other two blocks thoothukudi and radhapuram is non endemic from fluoride ion but has high TDS, hardness, chloride. The estimated maximum exposure dose for infants is being 0.075 mg/kg/day, children 0.135mg/Kg/day and adults 0.13 mg/kg/day, but the minimal safe level for infants is 0.01 mg/kg/day and 0.05 mg/kg/day for children and adult, so a health threat is noticeable. Hence it is suggested that in fluoride affected areas preventive programs and defluoridation techniques, water management can be elucidated to the people. As fluoride is also required for dental development, the places where nil or less than 1 mg/L of fluoride concentration, fluoridation methods can be suggested

## General Terms

mg/L – milligram per liter, N-North, S-South, E-East, W-West, M-Middle, GIS-Geographic Information System, TDS-Total Dissolved Solids, L/d- Litre per day, Kg-Kilogram, SD-Standard Deviation ,WHO-World Health Organisation, mg/kg/d- milligram per kilogram per day, USPHS-United State Public Health Service, APHA-American Public Health Association

## Keywords

Fluoride, Fluorosis, groundwaterquality, GIS, Exposure dose

## 1. INTRODUCTION

Fluoride exists naturally in water sources and is derived from fluorine, the thirteenth most common element in the earth's crust .It is found in trace quantities in soil, plants and animals [1,2]. Fluoride is beneficial micronutrient to human beings for bone formation and calcification of dental enamel when present in low concentration ,it is strongly electronegative which is attracted by positively charged calcium in teeth and bones which may be beneficial at lower concentration and detrimental at higher concentration[3]. The WHO recommends tolerance limit for fluoride in Drinking water as 1.5 mg/L (WHO, Guidelines for Drinking water quality Vol.2, World Health Organization ,Geneva, 1984, pg.249). Water is found in abundance as fresh water and salt water, in which, fresh water is the only resource for drinking purpose as well as for industries and agriculture. Fresh water is in the form of surface water and ground water. These water resources which are unevenly distributed is deteriorated due to anthropogenic activities. Ground water is considered as the major source of drinking water in rural as well as in urban areas, as no or less often treatment is required to be utilized. Though groundwater contributes only 0.6% of the total water resources on earth, developing country like India prefers ground water. Nearly 80% of total drinking water and 50% of agriculture need is contributed by the ground water source [4]

Fractured hard rock zone with pegmatite veins have abnormal level of fluoride .It is also evident that in India, igneous and metamorphic rock, anthropogenic activities like fertilizer industry ,pesticide ,sewage and sludge ,overexploitation ,unskilled utilization had elevated the concentration of fluoride in ground water contaminating the shallow aquifers[5,6]

Presence of fluoride was reported in 17 states of India. In tamilnadu - nilakottai block ,Uttarpradesh - sonbhadra district, Andhrapradesh -Prakasham District, Haryana - Jind district was Severely affected by fluoride. It was also found that 88% villages in tamilnadu are affected by fluoride. The maximum allowable concentration of fluoride was 1.5mg/L as per Indian Standards[1,7,8,9]. USPHS ,1962 has given the allowable fluoride concentration depending upon the climatic conditions as shown in table 1, which highlights the maximum allowable concentration for fluoride for drinking water in Indian conditions as 1.4 mg/L[9]. The present study deals with the prediction of fluoride level and physicochemical parameters from the borewell samples collected from four blocks namely thiruchendur, udangudi, thoothukudi and Radhapuram of south tamilnadu.

**Table 1: Maximum allowable fluoride Concentration range as per USPHS**

Annual average of maximum air temperature °C	Recommended fluoride concentration (mg/L)			Maximum allowable fluoride concentration (mg/L)
	Lower	Optimum	Upper	
10-12	0.9	1.2	1.7	2.4
12.1-14.6	0.8	1.1	1.5	2.2
14.7-17.7	0.8	1.0	1.3	2.0
17.8-21.4	0.7	0.9	1.2	1.8
21.5-26.2	0.7	0.8	1.0	1.6
26.3-32.5	0.6	0.7	0.8	1.4

## 2. IMPACTS OF FLUORIDE

Fluoride not only enters the human body through drinking water, it also get inside through unintentional ingestion of toothpaste, mouth rinses and other dietary sources like tea, food, drugs, cosmetics and drinks prepared with fluoridated water [9]. A number of variables influence the amount of fluoride absorbed, including age, type of fluoride compound, pH condition and concentration of other ions [2].

Fluoride content in drinking water exhibit a linear relationship with dental fluorosis, the enamel of the teeth is affected by mottling and brownish discoloration, severe pitting and surface chipping. In highly endemic areas the deciduous teeth may be affected. Fluorosis affecting bone is not detectable in temperate areas until the concentration of fluoride is greater than 4 ppm and large quantity of water consumption in tropical places may develop fluorosis with consuming lower concentration of fluoride water. Back stiffness and limb pains are radiological evidence of skeletal fluorosis. Gross crippling deformities of hips and knees and dual locomotor, neurological disability are the additional effects caused by fluorosis [10]. Other health effects include immunological effects, reducing lactation, birth defects like down syndrome, Renel effects, gastrointestinal tract disturbances, reduction in children's intelligence, thyroid. The other indirect effects on adding fluoride to water increased leaching of lead from pipes and aluminum from cooking utensils [2].

In agriculture fluoride inhibits plant metabolism, leading to necrosis, needle smatch and tip burn diseases. Fluoride salts are toxic with higher concentration. Sodium Fluoride lethal dose was depicted in the table2, poisoning comes from ingesting a large amount of fluoride in short period [11]

**Table 2: Lethal dosage of fluoride**

Age group	Lethal dosage (mg/Kg of body weight)
Adult	32-64
Children above 6 years	16
Children under 6 years	5

Dietary intake recommendation by A.Hardisson, M.I.Rodriguez was 0.1 and 1 mg/person/day for the Infants less than one year, 0.5 and 1.5 mg/person/day for children less than three year, upto 2.5 mg/person/day for less than upto 12 year and 1.5 and 4 mg/person/day for adults [12].

Some people in villages like paramankurichi, nallur, Moolakarai have identifiable stains in their teeth which may

be the indication of dental fluorosis, hence the study was conducted to know the fluoride concentration level.

## 3. MATERIALS AND METHOD

### 3.1 Collection of bore well samples

A total of 400 bore hole samples were collected randomly from different locations of udangudi, thiruchnedur, Tuticorin and Radhapuram of south tamilnadu during post monsoon month of august –September 2010, when there was practically no rainfall and the average maximum and minimum temperature remain 37°C to 32°C respectively. All the samples were collected in a precleaned and sterilized polyethylene bottle of one liter capacity. On the arrival to the laboratory it was preserved at 4°C.

### 3.2 Analysis of Samples

The physio-chemical parameters like conductivity was analysed using conductivity meter, TDS using TDS meter, pH using pH meter, Alkalinity was estimated by titrating with Hydrochloric acid, Chloride was estimated by standard Silver nitrate, hardness by titration with standard EDTA. Sulphate was analyzed using UV-Visible Spectrophotometer. The procedure was followed referring the APHA, 1989 standard methods. Fluoride was analyzed using Fluoride Ion Selective Electrode 9609 BNWP with Orion Ion Meter, Total Ionic Strength Adjustment Buffer solution (TISAB) was prepared and added in 1:1 proportion in order to prevent the interruption of other ions while measuring fluoride. Calibration of the instrument is done with standards one with lower concentration and other with higher concentration, where the unknown lies between those two standards. Continuous stirring of standards and samples was done before measuring. The unknown concentration of fluoride was directly read from the digital display of the Orion ion meter.

### 3.3 Mapping of Fluorotic Area

After analyzing the fluoride level in the bore hole samples of four blocks, the fluoride level >1.5 mg/L, and <1.5 mg/L was mapped using Arc GIS version 9.3 Software to clearly identify the places which require defluoridation and fluoridation.

### 3.4 Evaluation of Fluoride Exposure dose

The following equation was used to calculate the fluoride exposure dose for the four blocks which was used by Gopalan Viswanathan [1]

$$\text{Exposure Dose} = \frac{C \times WI}{BW}$$

Where, C- Fluoride Concentration (mg/L), WI-Water Intake (L/d), BW – Body weight (Kg)

The water intake for different age groups was taken as, 250ml of boiled water per day for the Infants of 0 -6 months age group in the form of milk formulas. The Children and adults of 7 year and above 19 years consume 1.5 and 5 L/day. The body weight of infants is taken as 6 kg and children as 20 kg and adults as 70 kg. For the minimum and maximum exposure dosage evaluation, the mean of minimum and maximum range of fluoride level at each block was considered

### 3.5 Statistical Analysis

Mean and Standard deviation values were calculated for various fluoride levels measured. The range of fluoride was tabulated for the samples for each village. The correlation

analysis was performed between different age groups . The graphs were plotted using Microsoft Excel sheets.


**Table3 Fluoride level in Thiruchendur block**

Name of the Village	Fluoride Level in mg/L					Mean $\pm$ SD <sup>a</sup>	Range
	N	S	E	W	M		
Ammanpuram	1	0.22	1.56	1.2	0.92	0.98 $\pm$ 0.44	0.22-1.2
Kayamozhi	0	0.18	0.16	0.13	0.14	0.12 $\pm$ 0.06	0-0.18
Moolakarai	1.0	0.7	0.9	0.2	1.8	0.92 $\pm$ 0.52	0.2-1.8
Mela Thiruchendur	4.8	0.43	0.2	3.2	3.2	2.37 $\pm$ 1.78	0.2-4.8
Mela Pudukkudi	0.12	0.076	1.2	0.54	0.33	0.45 $\pm$ 0.41	0.12-1.2
Nallur	1.6	4.2	0.25	1.3	1.9	1.85 $\pm$ 1.30	0.25-4.2
Pallipathu	0.85	1.5	1.3	1.23	1.45	1.27 $\pm$ 0.23	0.85-1.5
Pitchivilai	0.36	0.13	0.11	0.28	0.34	0.24 $\pm$ 0.10	0.11-0.36
Verrapandian patnam	0.8	0.39	1.0	1.25	0.78	0.84 $\pm$ 0.28	0.78-1.25
Verrapandian patnam.R	0.12	0.55	0.11	0.22	0	0.20 $\pm$ 0.19	0-0.55
Veeramanickam	2.8	0.25	1.2	0.87	0.32	1.09 $\pm$ 0.93	0.25-2.8

**Table4 Fluoride level in Udangudi block**

Name of the Village	Fluoride Level in mg/L					Mean $\pm$ SD <sup>a</sup>	Range
	N	S	E	W	M		
Athiyakurichi	0.7	0.5	0.47	0.65	0.66	0.60 $\pm$ 0.09	0.45-0.7
Chettiapathu	0.8	0.9	0.95	0.1	0.33	0.62 $\pm$ 0.34	0.1-0.95
Kulasekaranpattinam	0.99	0.63	0.31	2.2	0.78	0.98 $\pm$ 0.65	0.31-2.2
Kuthiraimozhi	0.13	0.35	0.35	0.16	0.092	0.22 $\pm$ 0.11	0.092-0.35
Lakshmiapuram	0	0	0	0.0077	0.12	0.03 $\pm$ 0.05	0-0.12
Manapadu	1.7	2.2	1.7	1.8	2.1	1.90 $\pm$ 0.21	1.7-2.2
Manadu Thandupathu	0.070	0.12	0.19	0	0.070	0.09 $\pm$ 0.06	0-0.19
Mathavankurichi	2.7	2.2	1.9	2.2	2.5	2.30 $\pm$ 0.28	1.9-2.7
Meingapuram	0	0.13	0	0	0	0.03 $\pm$ 0.05	0-0.13
Nainapathu	1.9	1.7	1.4	1.7	1.7	1.68 $\pm$ 0.16	1.4-1.9
Nangaimozhi	0.1	0.3	0.22	0.35	0.39	0.27 $\pm$ 0.10	0.1-0.39
Paramankurichi	0.57	1.7	0.63	2.2	2.7	1.56 $\pm$ 0.85	0.57-2.7
Seerukatchi	0	0	0	0.0028	0	0 $\pm$ 0	0-0.0028
Semmarikulam	0	0	0.049	0.049	0.41	0.10 $\pm$ 0.16	0-0.41
Sirunadar kudieruppu	4.8	5.1	4.3	5.6	2.3	4.42 $\pm$ 1.14	2.3-5.6
Vellanvilai	1.6	1.7	1.9	1.7	1.9	1.76 $\pm$ 0.12	1.6-1.9
Venkattaramanujapuram	0	0.048	0	0.048	0	0.02 $\pm$ 0.02	0-0.048

**Table5 Fluoride level in Thoothukudi block**

Name of the Village	Fluoride Level in mg/L					Mean $\pm$ SD <sup>a</sup>	Range
	N	S	E	W	M		
Alligulam	0	0	0.026	0	0	0.01 $\pm$ 0.01	0-0.026
Athimarapatti	0.02	0.3	0.35	0.23	0.15	0.21 $\pm$ 0.12	0.02-0.35
Ayyanadaippu	0.016	0.014	0.016	0.34	0.72	0.22 $\pm$ 0.28	0.014-0.72
Dalavaipuram	1.4	1.6	0.0024	1.6	1.3	1.18 $\pm$ 0.60	0.0024-1.6
Kattalankulam	0.11	0.17	0.19	0.12	0.13	0.14 $\pm$ 0.03	0.11-0.19
Keela Thattaparai	0.3	0.2	0.1	0.15	0.11	0.17 $\pm$ 0.07	0.1-0.3
Kootudankadu	0.01	0.093	0.015	0.024	0	0.03 $\pm$ 0.03	0-0.093
Korampallam	1.1	0.47	1.4	1.4	1.2	1.11 $\pm$ 0.34	0.47-1.4
Kulayankarisal	0.01	0.10	0.026	0.011	0.12	0.05 $\pm$ 0.05	0.011-0.12
Kumaragiri	0.031	0.056	0.054	0.21	0.1	0.09 $\pm$ 0.06	0.031-0.21
Mapillaiurani	0.1	0.3	0	0	0.22	0.12 $\pm$ 0.12	0-0.3
Maravanmadam	0	0	0.31	0.16	0.15	0.12 $\pm$ 0.12	0-0.31
Meelavittan	0.43	0.55	0.63	0.5	0.034	0.43 $\pm$ 0.21	0.034-0.63

Mella Thattaparai	0.4	0.1	0.1	0.2	0.1	0.18±0.12	0.1-0.4
Mudivaitanendal	0.035	0.079	0.1	0.01	0.11	0.07±0.04	0.035-0.11
Mullukadu	0.5	0.6	0.66	0.7	0.79	0.65±0.10	0.5-0.79
Muthaihpuram	0.090	0.18	0.66	0.64	0.15	0.34±0.25	0.090-0.66
Sankaraperi	0.16	0	0.36	0	0.17	0.14±0.13	0-0.36
Servaikaranmadam	0.5	0.3	0.2	0.11	0.13	0.25±0.14	0.11-0.5
Therukku Silukkanpatti	0.5	0.45	0.56	0.3	0.36	0.43±0.09	0.3-0.56
Thimmarajapuram	0.67	0.47	0	0.094	0	0.25±0.27	0-0.67
Thoothukudi Rural	0.3	0.32	0.4	0.51	0.33	0.37±0.08	0.3-0.51
Umarikottai	0.15	0.23	0.22	0.11	0.17	0.18±0.04	0.11-0.23
Vadaku Silukkanpatti	0.60	0.40	0.84	0.82	0.93	0.72±0.19	0.40-0.93
Varthagareddipatti	0.56	0.52	0.55	0.12	0.18	0.39±0.19	0.12-0.56

**Table6 Fluoride level in Radhapuram block**

Name of the Village	Fluoride Level in mg/L					Mean ±SD <sup>a</sup>	Range
	N	S	E	W	M		
Vijayapathi	1.0	1.2	0.1	0.2	0.6	0.62±0.43	0.1-1.2
Koodankulam	0.16	0.24	0.50	0.55	0.16	0.32±0.17	0.16-0.55
Radhapuram	0.3	0.36	0.36	0.72	0.15	0.38±0.19	0.15-0.72
Samugarengapuram	0.31	0.76	0.16	0.76	0.33	0.46±0.25	0.16-0.76
Ovari	0.6	1.1	0.7	0.2	0.4	0.60±0.30	0.2-1.1
T.Kallikulam	0.14	0.15	0.15	0.18	0.14	0.15±0.01	0.14-0.18
Kuttam	0.2	0.32	0.35	0.4	0.45	0.34±0.08	0.2-0.45
Urumankulam	0.15	0.18	0.11	0.1	0.21	0.15±0.04	0.1-0.21
Karisuthu pudur	0.028	0	0.06	0.044	0.059	0.04±0.02	0-0.06
Karaisuthu Navaladi	0.034	0.03	0.025	0.022	0.034	0.03±0.00	0.022-0.034
Koonthankulam	0.4	0.42	0.31	0.36	0.41	0.38±0.04	0.31-0.42
Thiruvambalapuram	0	0	0.12	0.2	0	0.06±0.08	0-0.2
Kumarapuram	0.031	0.056	0.054	0.21	0.12	0.09±0.07	0.031-0.21
Karaisuthu Ovari	1.0	0.9	0.88	0.81	0.75	0.87±0.08	0.75-1.0
Kottaikurukulam	0.26	0.27	0.47	0.48	0.087	0.31±0.15	0.087-0.48
Mudumuthanmozhi	0.091	0.1	0.11	0.13	0.092	0.10±0.01	0.091-0.13
Kasthuriengapuram	0.9	0.4	0.2	0.5	0.6	0.52±0.23	0.2-0.9
Kumbikulam	0.5	0.4	0.43	0.49	0.52	0.47±0.05	0.4-0.52
Udayathur	0.12	0.60	0.057	0	0.49	0.25±0.24	0-0.60
Chidambarapuram	0.57	0.55	0.57	0.57	0.53	0.56±0.02	0.53-0.57
Edayankudi	0.19	0.18	0.17	0.18	0.2	0.18±0.01	0.17-0.2
Sundarapandiyapuram	0.12	0.12	0.085	0.13	0.14	0.12±0.02	0.085-0.14
Parameswarapuram	0.22	0.36	0.080	0.024	0.058	0.15±0.13	0.024-0.36
Anaikudi	0.24	0.23	0.22	0.22	0.23	0.23±0.01	0.22-0.24
Appuvilai	0	0	0	0.01	0.022	0.01±0.01	0-0.022
Anaikarai	0.05	0.012	0.1	0.17	0.15	0.10±0.06	0.012-0.17
Mahadevanallur	1.0	0.9	0.8	0.6	0.75	0.81±0.14	0.6-1.0

**Table7 Fluoride level of the four blocks**

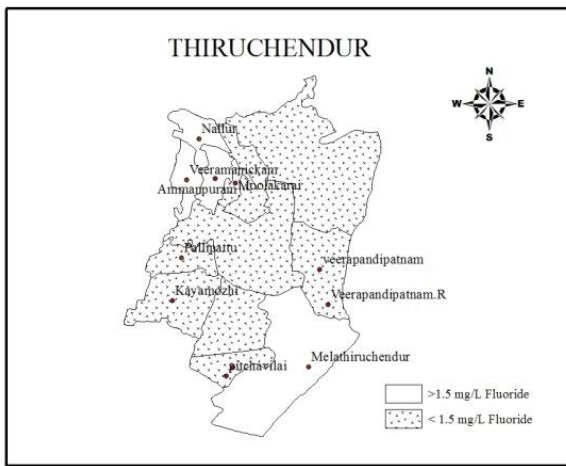
Name of the block	No. of village	No. of samples	No. of Sample >3mg/L	No. of Sample between 1.5-3 mg/L	No. of Sample between 0.5-1.5 mg/L	No. of Sample <0.5 mg/L	Mean ±S.D
Thiruchendur	11	55	4	5	21	25	0.94±0.57
Udangudi	17	85	4	24	13	44	0.97±0.26
Thoothukudi	25	125	Nil	2	29	94	0.31±0.15
Radhapuram	27	135	Nil	Nil	32	103	0.31±0.11

**Table 8 Exposure dosage of Infants, Children, Adults In four blocks mg/L**

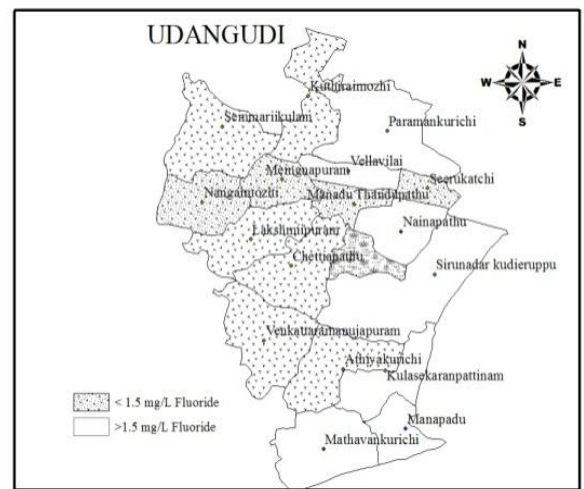
Name of the block	Mean $\pm$ S.D	Infants in mg/kg/day	Children in mg/kg/day	Adults in mg/kg/day
Thiruchendur	0.94 $\pm$ 0.57	0.02-0.06	0.03-0.11	0.03-0.1
Udangudi	0.97 $\pm$ 0.26	0.03-0.05	0.05-0.09	0.05-0.1
Thoothukudi	0.31 $\pm$ 0.15	0.01-0.02	0.01-0.03	0.01-0.03
Radhapuram	0.31 $\pm$ 0.11	0.01-0.02	0.02-0.03	0.014-0.03

**Table 9 Maximum Exposure dosage in mg/day**

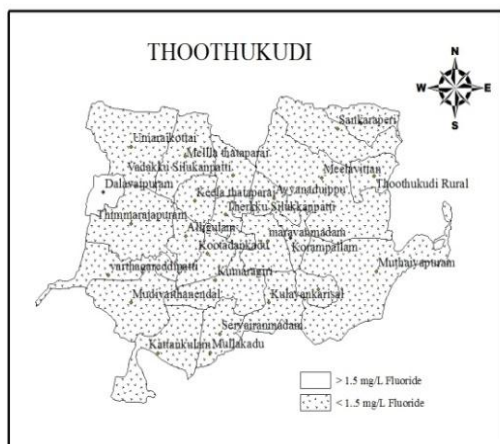
Water fluoride level mg/L	Maximum Exposure dose mg/day		
	Infants	Children	Adults
0.94	0.06	0.11	0.1
0.97	0.05	0.09	0.1
0.31	0.02	0.03	0.03
0.31	0.02	0.03	0.03



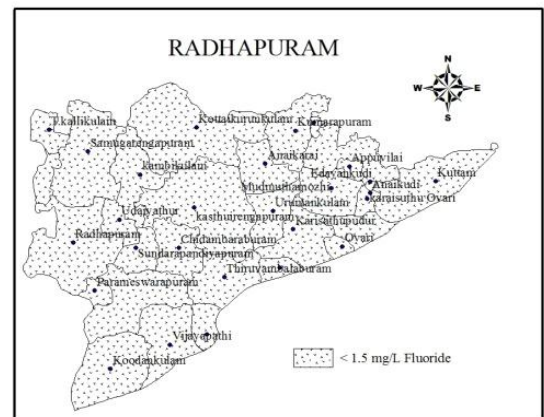
**Figure 1: Fluoride level in Thiruchendur block**



**Figure 2: Fluoride level in Udangudi block**



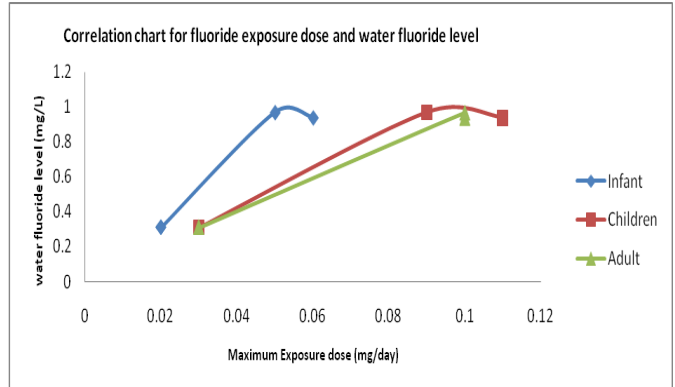
**Figure 3: Fluoride level in Thoothukudi block**



**Figure 4: Fluoride level in Radhapuram block**

**Table 9 Maximum Exposure dosage in mg/day**

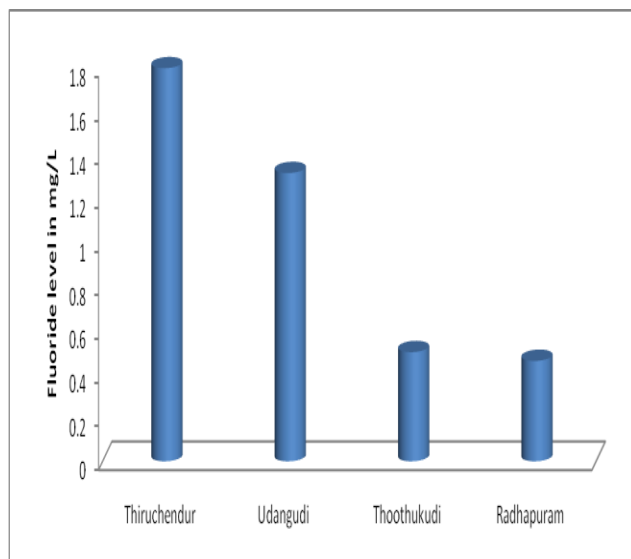
Water fluoride level mg/L	Maximum Exposure dose mg/day		
	Infants	Children	Adults
0.94	0.06	0.11	0.1
0.97	0.05	0.09	0.1
0.31	0.02	0.03	0.03
0.31	0.02	0.03	0.03



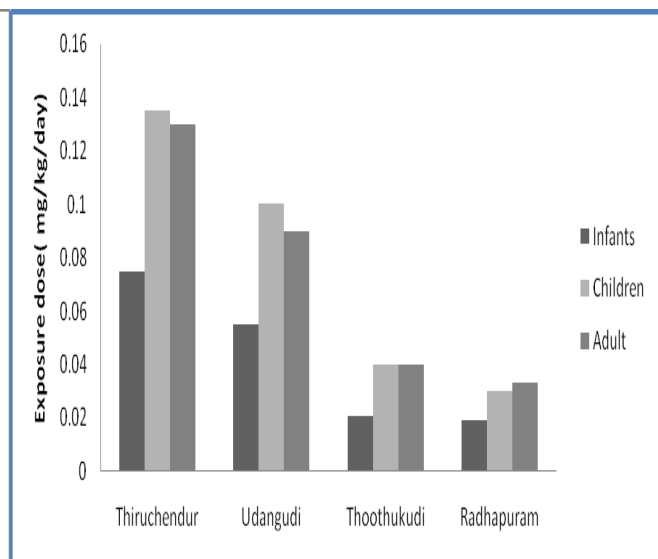
**Figure 5: Correlation chart for fluoride exposure dose and water fluoride level**

**Table 10 Correlation Co-efficient between different age groups**

Age group	Regression equation	Co-efficient of determination (R <sup>2</sup> )	Correlation Coefficient (r)	Significant level	Confidence level
Infants	y=17.58x-0.027	0.947	0.973	0.0001	0.898
Children	Y=8.794x+0.060	0.947	0.973	0.0001	0.8760
Adult	Y=9.214x+0.033	0.998	0.999	0.0001	0.8760



**Figure 6: Mean fluoride level in four blocks**



**Figure7: Exposure dosage of different age groups in four blocks**

**Table 11 Minimum and Maximum Exposure dosage between different age groups of four blocks**

Name of the block	Mean value of minimum and maximum fluoride range in mg/L	Infants		Children		Adults	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Thiruchendur	0.27 – 1.8	0.0133	0.075	0.02	0.135	0.02	0.13
Udangudi	0.62 – 1.32	0.026	0.055	0.05	0.1	0.04	0.09
Thoothukudi	0.11 – 0.50	0.0046	0.021	0.008	0.04	0.008	0.04
Radhapuram	0.18 – 0.46	0.0075	0.019	0.0006	0.03	0.013	0.033

**Table 12 Comparison of physio chemical parameters of the groundwater from the four blocks with standard drinking water (Indian and WHO)**

Parameters	Values from the collected ground water samples			Indian Standards		WHO Standards
	Maximum	Minimum	Mean	Acceptable	maximum	
EC	13	0.012	6.506	300	-	-
TDS	8790	86	4438	500	1500	500
pH	8.9	6.34	7.62	7-8.5	6.5-9.2	6.5-9.2
Alkalinity	956	48	502	200	600	-
Chloride	5008.46	0	5008.46	200	1000	500
Hardness	2844	50	1447	200	600	500
Sulphate	285.05	3.05	144.05	200	400	-
Fluoride	5.6	0	5.6	1.0	1.5	-

**Table 13 Groundwater samples classification on the basis total Total dissolved salts in four blocks**

Classification of ground water	Total Dissolved Salts (mg/L)	No. of samples
Non –Saline	<1000	263
Slightly Saline	1000-3000	106
Moderately	3000-10000	31
Very Saline	>10000	Nil

**Table 14 Ground water sample classification based on hardness in four blocks**

Classification of ground water	Hardness (mg/L)	No. of samples
Soft	0-60	03
Moderately hard	61-120	15
Hard	121-180	39
Very Hard	>180	343

## 4. DISCUSSION RELATED TO FLUORIDE AND CORRELATION CO-EFFICIENT

### 4.1 Thiruchendur Block

A total of 55 number of samples were collected from 11 villages of this block. Among those villages, 7.2% bore hole samples from four locations contain more than 3 mg/L of fluoride, 9.09% borehole samples had fluoride between 1.5 to 3 mg/L, 38.18% borehole samples had fluoride between 0.5 to 1.5 mg/L, 45.45% borehole samples had fluoride less than 0.5 mg/L. The fluoride level in the individual blocks was given in table 7. The exposure dose calculated was given in table 8, the infants exposure level was between 0.02-0.06 mg/kg/day, Children was between 0.03- 0.11 mg/kg/day and for adults was between 0.02-0.06 mg/kg/day. Akin trend was observed at vadamadurai block by Gopalan viswanathan et al (2009). The maximum exposure dose for the blocks was given in table 9. On the whole, mean fluoride sample collected from all villages in the block was 0.94 and the standard deviation was 0.57. The fluoride level in the groundwater of all the villages in thiruchendur block was listed in table.3

### 4.2 Udanagudi Block

Bore hole samples of nearly 85 samples were collected from 17 villages from udangudi block. Among those villages 4.7% bore hole samples had fluoride more than 3 mg/L, 28.24% bore hole samples had fluoride between 1.5 to 3 mg/L, 15.29% borehole samples had fluoride between 0.5 to 1.5 mg/L, 51.76% bore hole samples has fluoride less than 0.5 mg/L. The exposure dose calculated for Infants was 0.03 - 0.05mg/Kg/day, Children between 0.05-0.09 mg/Kg/day and Adults between 0.03-0.05 mg/Kg/day. On the whole mean samples collected from all villages in the block was 0.97 and

standard deviation of 0.20. The fluoride level in the bore hole water samples of udangudi was listed in table 4

### 4.3 Thoothukudi Block

Bore hole samples of nearly 125 numbers were collected from 25 villages of thoothukudi block. Among those villages, no bore hole samples had fluoride ion greater than 3 mg/L, 1.6% of bore hole samples had fluoride level between 1.5-3mg/L, 75.2% of bore hole samples had fluoride level less than 0.5 mg/L. The exposure dose calculated for infants was 0.01-0.02 mg/Kg/day and for children 0.01-0.03mg/Kg/day, Adults 0.01-0.02 mg/Kg/day which is less effective. The whole mean sample collected from all villages in the block was 0.31 and standard deviation of 0.15. The fluoride level in the bore hole water of all villages of thoothukudi block is listed in the table 5. This block is not endemic from fluorosis.

### 4.4 Radhapuram Block

Bore hole samples of 135 numbers were collected from all 27 villages of radhapuram block. Among those villages, no samples had fluoride level greater than 3 mg/L and between 1.5-3mg/L. 23.7% of bore hole samples had fluoride level between 0.5-1.5 mg/L, 76.29% of bore hole samples had fluoride level less than 0.5 mg/L. The exposure dose of fluoride in infants was 0.01-0.02 mg/Kg/day, children 0.02-0.03 mg/Kg/day, and adults 0.014-0.03 mg/Kg/day, which shows not much problem with fluoride ion except for infants. The mean value is being 0.31 and standard deviation is 0.11 for radhapuram block. This block is not endemic from fluorosis. The fluoride level in the bore hole water of all villages of thoothukudi block was listed in the table 6.

## 5. DISCUSSION RELATED WITH WATER QUALITY

Water quality parameters like pH, Conductivity, TDS, alkalinity, Hardness, chloride, sulphate were determined for

the samples collected using the standard methods, were the correlation co-efficient data for the water samples are calculated. The ground water samples had no colour, odour, turbidity. Most of the water samples taste slight saline. The ground water quality under the study was compared using drinking water standards (Indian and WHO) which are presented in table 12. The data showed variation in the samples with respect to chemical composition.

In thiruchendur block out of 55 samples, 34 samples has alkalinity exceeding the WHO acceptable limit 200mg/L. pH of the samples was slightly alkaline in most of the villages. 20 number of samples has TDS value exceeding WHO acceptable limit 500mg/L, 9 number of samples has hardness level exceeding the WHO acceptable limit 500mg/L. Similarly 11 numbers of sample has chloride content greater than WHO acceptable limit 500mg/L.

In Udangudi block, most of the samples has pH range within 6.5-8.5. The TDS level is exceeding the WHO acceptable limit for 61 numbers of samples. Alkalinity is higher in the village sirunadar kudieruppu. 41 number of samples has high chloride content, 42 number of samples has hardness greater than the WHO acceptable limit. Sulphate content is within the acceptable limit of Indian standards.

In thoothukudi block most of the samples has TDS, Chloride, Alkalinity and Hardness greater than WHO acceptable limit. pH values are within the acceptable limit. Except sankaraperi all the samples has sulphate ion concentration within the acceptable limit of Indian standards.

In Radhapuram block out of 135 samples, 61 number of samples has TDS level greater than WHO acceptable limit 500mg/L, 79 number of samples has alkalinity greater than WHO acceptable limit 200mg/L. Nearly 49 number of samples has alkalinity exceeding the acceptable limit 200mg/L. Chloride and Hardness values are higher than the WHO acceptable limit 500mg/L for 40 number of the sample at this block. Sulphate ion concentration is within the acceptable limits.

The samples of four blocks are classified for the total dissolved solids according to Rabinove et al listed in table 13, where 263 samples are non saline, 106 samples are slightly saline, 31 samples are moderately saline and no samples have salinity greater than 10000mg/L. Total Hardness is classified according to Durfor and Becker listed in table 14, in which 343 number of samples are very hard which implies that the water is not portable, 39 samples are hard water, 15 samples are moderately hard and only 3 samples are soft water [9]. The Correlation co-efficient for the water samples in four blocks shows positive correlation for the parameters analysed which was shown in table 15, 16, 17, 18. A good correlation was found between conductivity and TDS. A better correlation for fluoride ion was found with alkalinity.

## 6. IMPACT OF THE STUDY

The assessment of fluoride ion and other physio chemical characteristics in all the four blocks showed that the ground water is not suitable for drinking purpose. Thiruchendur and udangudi blocks have fluoride ion problems in some villages, continuous pumping of water from bore well results in lowering of water level which cause the ions to be concentrated. The infants and children intelligence may also be affected due to continual drinking of fluoride contaminated water [19]. Hence awareness programs should be conducted through public meetings, distributing pamphlets and

conducting visual aids, so that the people can be safeguarded from fluorosis and related problems.

## 7. CONCLUSION

Three villages in Thiruchendur block and seven villages in udangudi block has fluoride level greater than the permissible limits, stains in teeth are the indication of the initial stage of fluorosis. So awareness program can be conducted and proper water management should be explained to the people in order to safe guard the ground water. Proper methodology can be suggested to reduce the fluoride ion. As the water quality of the blocks are not satisfying the standards of potable water and good treatment system can be constructed. Mapping of fluoride ion gives an idea to know which place require fluoridation and defluoridation techniques. Defluoridation can be done with Nalgonda technique, adsorption methods using activated alumina, bone char etc. Fluoridation can be done using fluoridated tooth paste, mouth rinses, tablets, tonic, and tea. The statistical analysis apparently indicates that the root cause of fluoride exposure dose was due to water fluoride level in that particular village.

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