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Comparison of physicochemical parameters in the ground water samples of the fluorotic and nonfluorotic areas of Agastheeswaram Union, South India

A.Anita Joshi Raj[1], V.Umayoru Bhagan[2]
[1]*(Department of Chemistry, Ponjesly College of Engineering, Anna University, India)*
[2]*(N. I. College of Arts and Science, M.S University, India)*

***Abstract**: Fluoride Contamination of ground water is a growing problem in many parts of the world. This paper analyses the most extensive database on fluoride and other physicochemical parameters of 51 ground water samples of ten fluorotic and two nonfluorotic areas of Agastheeswaram Union, South India. The water samples from 10 fluorotic areas were tested and was found to have fluoride level ranging between 1.3 to 2.7 ppm which was greater than the permissible limit. Other parameters such as pH, total handness calcium, magnesium, sodium, potassium, chloride, salinity, alkalinity, electrical conductivity, sulphate, phosphate and aluminium were also measured. These values were compared with the values obtained from nonfluorotic area. Total handness, pH and alkalinity were found to be higher than the permissible limits in almost all the locations of 10 fluorotic areas at various seasons. Finally it was predicted that as alkalinity increases fluoride level increases in the ground water samples of Agastheeswaram Union.*
***Keywords:** Ground water, Fluoride, Fluorotic, Nonfluorotic, Physicochemical*

I. Introduction

Fluoride contamination of ground water has now become a major geo-environmental issue in many parts of the world due to its toxic effects even if consumed in trace quantities. Fluoride in ground water possess a great problem in most states of India [1]. Seventeen states in India has been identified as endemic for fluorosis and Tamil Nadu is one of them. The amount of fluoride occurring naturally in ground water is governed by climate, composition of host rocks and hydrogeology [2]. The fluoride content is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, temperature, pH, concentration of calcium and bicarbonate ions in water, etc [3].This study was carried out to assess the quality of underground water of ten fluorotic areas (I- Agastheeswaram, II-Anjugramam, III- Marungoor, IV-Mylady, V-South Thamaraikulam, VI-Theroor, VII -Mahadhanapuram, VIII-Theraikalpudur, IX-Kottaram and X-Nallur) and two nonfluorotic areas (I-Vadiveeswaram and II-Kanyakumari) of Agastheeswaram Union in South India. The fluoride concentrations along with various physicochemical parameters in ground water samples were determined in these regions. Moreover an attempt has been made to statistically correlate the concentrations of fluoride with other parameters and the conditions affecting the ground water quality.

II. Materials and Methods

51 underground water samples from ten fluorotic areas and three samples from nonfluorotic areas were collected in precleaned containers of one litre capacity. Temperature was measured immediately after the collection of samples. Water samples were analysed for fluoride within 24 hours of collection. A fluoride ion selective electrode (Orion 9609 BNWP) was used with TISAB-II solution in a 1:1 volume ratio with the samples. For calibration standard solutions containing 0.1, 1.0, 10.0, 100.0 ppm fluoride solutions prepared by serial dilution of a 1000 ppm fluoride stock solution with deionised water were employed. Along with fluoride, other physicochemical parameters were also analysed. The analysis involved the determination of total alkalinity, carbonate, bicarbonate using normal titrations and total hardness using complexometric titration, chloride using argentometric titration, pH using pH meter of systronic made, electrical conductivity, aluminum, sulphate and phosphate using UV spectrophotometer, sodium and potassium using flame photometer of systronics made.

III. Results and Discussion

3.1 Temperature

In the ten fluorotic and two control areas investigated the temperature varied between 28.1 ºC and 36.1ºC. The maximum temperature recorded was in fluorotic area VII in may and the minimum was recorded in fluorotic area I and II in December. According to the survey undertaken in fluorotic areas I to X, the temperature recorded was very high in summer ranging from 30.3ºC to 36.1ºC. As the temperature was very high in these areas the water level in bore wells came down and most of the samples showed higher values of total hardness, calcium, magnesium, electrical conductivity, sodium, chloride and salinity.

3.2 Fluoride

Table 4.1 shows the minimum and maximum values of fluoride in fluorotic and nonfluorotic areas. The amount of fluoride present in the ten fluorotic areas were in the range of 1.3 to 2.7ppm. Whereas in the non fluorotic areas the values of fluoride were within the prescribed limit. The concentration of fluoride in water was not uniform in the fluorotic areas. This may be due to the difference in the presence and accessibility of fluoride bearing minerals to the circulating water [4]. The area is devoid of hard rocks and hence the possibility of a source could be the fluoride bearing minerals [5].

3.3 pH

The minimum and maximum values of hydrogen ion concentrations are given in Table 4.2. Of the ten fluorotic areas the minimum value of 6.8 was found in V during the month of April and the maximum value of 8.9 was seen in I during the month of October. In general relatively high pH conditions have a tendency to displace fluoride ions from the mineral surface [6]. These results confirm the findings of the present investigation that as the pH level in the water becomes higher the fluoride level increases.

3.4 Electrical Conductivity

The values of electrical conductivity of all the fluorotic and nonfluorotic areas were given in Table 4.3. The maximum value of 1871 mho/cm was found in fluorotic area V during summer season and minimum of 913 mho/cm was seen in fluorotic area VI during rainy season. The low values of electrical conductivity indicate the lesser dissolution of carbonate minerals and other ionic species in water [7]. This causes the lowering of the conditions for the availability of fluoride [8].

3.5 Calcium

Table 4.4 shows the amount of calcium present in the ground water samples of ten fluorotic and two nonfluorotic areas. Of the ten fluorotic areas analysed fluorotic area VII showed the maximum of 250 ppm of calcium hardness during the month of April and fluorotic area IX showed the minimum of 15ppm during the month of october. It is an established fact that the water high in calcium are low in fluoride content [9]. Accordingly in the present investigation samples with low calcium had high fluoride levels.

3.6 Magnesium

The amount of magnesium present in the samples from the ten fluorotic areas are shown in Table 4.4. Of the ten fluorotic areas the fluorotic area VII showed the maximum of 118ppm magnesium hardness and the fluorotic area III recorded the minimum of 7ppm. Among the two nonfluorotic areas the maximum and minimum values were recorded in nonfluorotic area I and also those values were within the prescribed limit. In the summer season the values of magnesium hardness are higher than in the rainy season. This is due to the dilution of water. Hence magnesium is also one of the factors influencing the fluoride toxicity.

3.7 Total hardness

The results obtained for total hardness in the ten fluorotic and two nonfluorotic areas are given in Table 4.5. Among the ten fluorotic areas analysed, the fluorotic area VII was having maximum value of 341ppm and the minimum value was recorded in fluorotic areas II and III. Teotia et.al [10] have observed that increasing content of fluoride in water means a decrease in hardness. This applies to the majority of the samples. However in a few samples, as fluoride content in water increased, hardness also increased.

3.8 Carbonate and Bicarbonate

Table 4.6 shows the minimum and maximum values of carbonate and bicarbonate of ten fluorotic and two nonfluorotic areas. In the ten fluorotic areas the minimum value of carbonate was recorded in fluorotic area V and maximum of 73ppm was recorded in fluorotic area X. The minimum value of bicarbonate was found in fluorotic area X and maximum value of 643 ppm at V. It was noticed that almost all the samples had higher bicarbonate values than carbonate. So ground water of the study area are of bicarbonate type [11]. A positive relationship between fluoride and bicarbonate ion was observed as the concentration of bicarbonate was maximum [12].

3.9 Total alkalinity

The values of total alkalinity in the ten fluorotic and two nonfluorotic areas were given in the table 4.7. Higher values of alkalinity more than 600ppm was observed in fluorotic areas I,II,III, IV, V, VI, VII and VIII during the months of October, November and December when compared to summer season. During this period more fluoride concentration was also seen in the same areas. Where as in the nonfluorotic areas the values of total alkalinity and fluoride were within the prescribed limit. Hence no one was affected by fluorosis here. Saxena et.al [13] have observed that pH and fluoride has positive correlation, indicating that higher alkalinity of water promotes leaching of fluoride and thus affects the concentration of fluoride in the ground water.

3.10 Chloride and salinity

Table 4.8 shows the amount of chloride and salinity in the ground water samples of ten fluorotic and two nonfluorotic areas. Of the fluorotic areas, V showed the maximum values of chloride and salinity and fluorotic area I showed the minimum value of chloride and salinity. Higher values of chloride were seen during the month of April chloride did not show any correlation with fluoride content, ruling out evaporation as a reason for high fluoride content [14].

3.11 Sodium and Potassium

The levels of sodium and potassium in ten fluorotic and two nonfluorotic areas are given in table 4.9. Among the fluorotic areas, area II shows the maximum of 316ppm and minimum of 14ppm of sodium levels. Maximum value of potassium is seen in fluorotic area IV and minimum of 9.4 ppm in VI. In the nonfluorotic areas both the values were within the prescribed limit. In the fluorotic areas majority of the samples were found to have higher sodium content than potassium. Therefore sodium and potassium are also the factors enhancing fluoride toxicity.

3.12 Sulphate

The amount of sulphate present in the ground water samples of ten fluorotic and two nonfluorotic are shown in Table 4.10. Among the fluorotic areas the maximum value was seen in VIII (65 ppm) and minimum of 0.42ppm in II. Both these values were within the prescribed limit. The concentration of sulphate in the nonfluoritc areas were also found to be within the prescribed limit.

3.13 Phosphate

The phosphate levels in the ground water sources are shows in Table 4.11. Maximum value of 0.8 ppm was found in fluorotic area IV and minimum value of 0.01ppm was found in fluorotic areas II,III,IV,IX and X. The Phosphate values in all the fluorotic and nonfluorotic areas were within the prescribed limit.

3.14 Aluminium

The aluminium levels in the ground water sources are shown in Table 4.12. Maximum value of 0.06ppm was measured in fluorotic area I and III and minimum of 0.01ppm was found in I, II, III, IV, V, VI and VIII. The presence of residual aluminium in drinking water has become a major concern for public health. The WHO limit [15] for aluminium in drinking water is between 0.03 ppm to 0.2ppm. The values of aluminum in many of the fluorotic areas were found to be very low. Whereas the values in nonfluorotic areas were within the prescribed limit.

IV. Tables

Table : 4.1 Levels of fluoride in fluorotic and nonfluorotic areas

Fluorotic Areas	Minimum (ppm)	Maximum (ppm)
I	1.5	2.7
II	2.0	2.6
III	1.6	2.1
IV	1.6	2.2
V	1.5	2.0
VI	1.6	2.1
VII	1.9	2.1
VIII	1.5	1.7
IX	1.4	2.0
X	1.3	1.9
Nonfluorotic areas		

I	0.7	0.8
II	0.7	0.8

Table: 4.2 Levels of pH in fluorotic and nonfluorotic areas

Fluorotic areas	Minimum	Maximum
I	7.2	8.9
II	7.3	8.7
III	7.3	8.6
IV	6.9	8.6
V	6.8	8.7
VI	7.3	8.5
VII	7.5	8.5
VIII	7.4	8.5
IX	7.5	8.5
X	7.2	8.4
Nonfluorotic areas		
I	7.2	7.8
II	7.6	7.8

Table : 4.3 Levels of electrical conductivity in fluorotic and nonfluorotic areas

Fluorotic areas	Minimum (mho/cm)	Maximum (mho/cm)
I	1540	1720
II	938	1340
III	1299	1624
IV	1430	1817
V	1620	1871
VI	913	1223
VII	1001	1521
VIII	1002	1691
IX	1360	1559
X	1108	1326
Nonfluorotic areas		
I	902	1020
II	861	1010

Tables : 4.4 Levels of calcium and magnesium in fluorotic and nonfluorotic areas

Fluorotic areas	Calcium		Magnesium	
	Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)
I	61	135	11	81
II	43	185	22	55
III	50	130	7	81
IV	61	161	17	89
V	53	177	21	97

VI	43	138	22	63
VII	98	250	15	118
VIII	90	146	16	37
IX	15	230	20	95
X	62	120	30	56
Nonfluorotic areas				
I	81	233	15	50
II	88	253	22	28

Table : 4.5 Levels of total hardness in fluorotic and nonfluorotic

Fluorotic areas	Minimum (ppm)	Maximum (ppm)
I	101	174
II	67	205
III	62	183
IV	90	201
V	100	239
VI	97	164
VII	141	341
VIII	110	163
IX	101	270
X	110	159
Nonfluorotic areas		
I	104	279
II	100	281

Table : 4.6 Levels of carbonate and bicarbonate influorotic and nonfluorotic areas

Fluorotic areas	Carbonate		Bicarbonate	
	Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)
I	20	197	193	379
II	17	145	274	396
III	18	192	59	442
IV	35	184	223	445
V	10	172	291	643
VI	28	191	167	393
VII	29	198	139	581
VIII	14	196	220	464
IX	25	193	102	465
X	73	165	72	467
Nonfluorotic areas				
I	31	89	207	264
II	29	138	208	270

Table : 4.7 Levels of total alkalinity in fluorotic and nonfluorotic areas

Fluorotic areas	Minimum (ppm)	Maximum (ppm)
I	236	495
II	310	489
III	220	595
IV	326	605
V	344	695
VI	231	584
VII	174	628
VIII	234	652
IX	154	565
X	145	632
Nonfluorotic areas		
I	266	299
II	292	346

Table: 4.8 Levels of chloride and salinity in fluorotic and nonfluorotic areas

Fluorotic areas	Chloride		Salinity	
	Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)
I	8	92	14	166
II	36	123	65	223
III	201	206	362	372
IV	103	120	186	216
V	129	229	236	413
VI	132	184	238	332
VII	127	184	230	332
VIII	132	158	238	283
IX	127	208	230	375
X	193	208	354	375
Nonfluorotic areas				
I	68	69	124	125
II	32	76	58	137

Table: 4.9 Levels of sodium and potassium in fluorotic and nonfluorotic areas

Fluorotic areas	Sodium		Potassium	
	Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)
I	25	92	3	38
II	83	316	1.1	14.8
III	52	241	13	61
IV	201	285	54	81
V	98	206	6.1	14.8
VI	73	133	3.9	9.4
VII	14	90	7	21

VIII	75	78	10	16
IX	130	238	5	11.4
X	173	225	55	66
Nonfluorotic areas				
I	72	86	5.1	5.6
II	62	152	3.3	7.5

Table: 4.10 Levels of sulphate in fluorotic and nonfluorotic areas

Fluorotic areas	Minimum (ppm)	Maximum (ppm)
I	0.46	8.01
II	0.42	4.67
III	1.1	4.5
IV	6	27
V	3.16	6.25
VI	20	37
VII	20	47
VIII	14	65
IX	1.12	4.81
X	1.06	1.35
Nonfluorotic areas		
I	0.41	1.43
II	0.51	1.43

Table: 4.11 Levels of phosphate in fluorotic and nonfluorotic areas

Fluorotic areas	Minimum (ppm)	Maximum (ppm)
I	0.02	0.54
II	0.01	0.05
III	0.01	0.07
IV	0.02	0.8
V	0.01	0.07
VI	0.02	0.23
VII	0.02	0.04
VIII	0.03	0.05
IX	0.01	0.06
X	0.01	0.04
Nonfluorotic areas		
I	0.02	0.04
II	0.02	0.05

Table : 4.12 Levels of aluminum in fluorotic and nonfluorotic areas

Fluorotic areas	Minimum (ppm)	Maximum (ppm)
I	0.01	0.06
II	0.01	0.05
III	0.01	0.06
IV	0.01	0.05
V	0.01	0.04
VI	0.01	0.03
VII	0.02	0.03
VIII	0.01	0.03
IX	0.03	0.04
X	0.03	0.05
Nonfluorotic areas		
I	0.03	0.04
II	0.03	0.05

V. Conclusion

The ground water sources in the Agastheeswaram Union of Kanyakumari District, South India have been evaluated for its chemical composition and suitability for domestic uses with special concern of fluoride. Most of the samples do not meet the water quality standards for fluoride concentration and other quality parameters such as alkalinity, pH and hardness. Hence, it is not suitable for consumption without any prior treatment. Villagers should be educated about the hazards of consumption of high fluoride bearing water and use of simple methods of defluoridation using locally available low cost adsorbents. More emphasis must be given to calcium and phosphorus rich food as its intake helps in reduction in the absorption of fluoride in the intestine.

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