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Assessment of Groundwater Quality with special reference to fluoride in South Eastern part of Anantapur District, Andhra Pradesh

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ABSTRACT

The fluoride concentration in underground water was determined in Southwestern part of Anantapur district, Andhra Pradesh (India) where it is the only source of drinking water. Various other water quality parameters such as pH, electrical conductivity, total dissolved salts, total hardness, total alkalinity as well as sodium, potassium, calcium, magnesium, carbonate, bicarbonate, chloride and sulfate concentrations were also measured. The analytical results indicated considerable variations among the analyzed samples with respect to their chemical composition. Majority of the samples do not comply with Indian as well as WHO standards for most of the water quality parameters measured. The fluoride concentration in the underground water of these villages varied from 0.5 mg/l and 5.5 mg/l causing dental and skeletal fluorosis. Overall water quality was found unsatisfactory for drinking purposes without any prior treatment.

Key words: Groundwater quality, Fluoride concentration, dental and skeletal fluorosis, South Eastern part of Anantapur District, Andhra Pradesh.

INTRODUCTION

Water plays an important role in the development of a healthy society. 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 water is one of the prime factors on which the suitability of water for domestic, industrial and agriculture purpose depends. Fresh water occurs as surface water and ground water in this groundwater contributes only 0.6% of the total water resources on earth. It is major and preferred source of drinking water in rural and urban areas particularly in India. Water content many minerals like calcium, magnesium and fluoride etc. in this fluoride essential in minute quantity for normal mineralization of bone and teeth (for formation of dental enamel) fluoride stimulate growth of many plant species but on other hand when fluoride is taken up in excessive amount may prove toxic to plant and on feeding may toxic to animal and human as fluorosis. Fluoride concentration in drinking water is important for public health. Fluoride contributes to dental health and to the maintenance of appropriate bone density. Groundwater with high and low concentration of fluoride is found in many parts of the world. Fluorosis is endemic in several countries viz. China, South Africa, West indices, Ethiopia, Sri Lanka, Spain, Holland, Italy, Mexico etc. People of different regions of India, are also badly affected from Fluorosis. It is estimated that about 65 million people of India are suffer from Fluorosis. An inventory of fluoride concentration in drinking groundwater is important to curb spread of the disease fluorosis. This study was carried out to assess the quality of underground water of southwestern part of Anantapur district, Andhra Pradesh, India. The fluoride concentration along with various chemical parameters in ground water samples was determined in this region.

Study Area:
Anantapur District is located in the South-Western part of Andhra Pradesh, India. The study area lies between longitudes 77^0 30' - 78^0 15' east and latitudes 14^0 0' - 14^0 30' north and falls in the Survey of India Toposheet No:

57 F/14, F/15, J/3, J/4. The location map of the study area is shown in figure 1. The study area is mainly underlain by peninsular gneisses of Archean age. The major geomorphic units of the study area are Denudational Hills, Dissected pedimonts, Pediplain, and Alluvium. The study area comprises pink Granites, schists, composite gneisses of Dharwar intruded by a few pegmatite dykes and numerous dolerite dykes and the possible diamondiferous volcanic pipes. Geology of the study area is shown in the figure -2. The area experiences a semiarid climate (it has a moisture index of 33.7 %) with mean monthly temperatures of 15°C in January to 39°C in May. The normal rainfall of the district is 553 mm by which it secures least rainfall when compared to Rayalaseema and other parts of Andhra Pradesh. The area under study is mostly cultivated where maize, groundnut and cotton are grown. Paddy is also grown where there are some irrigation wells.

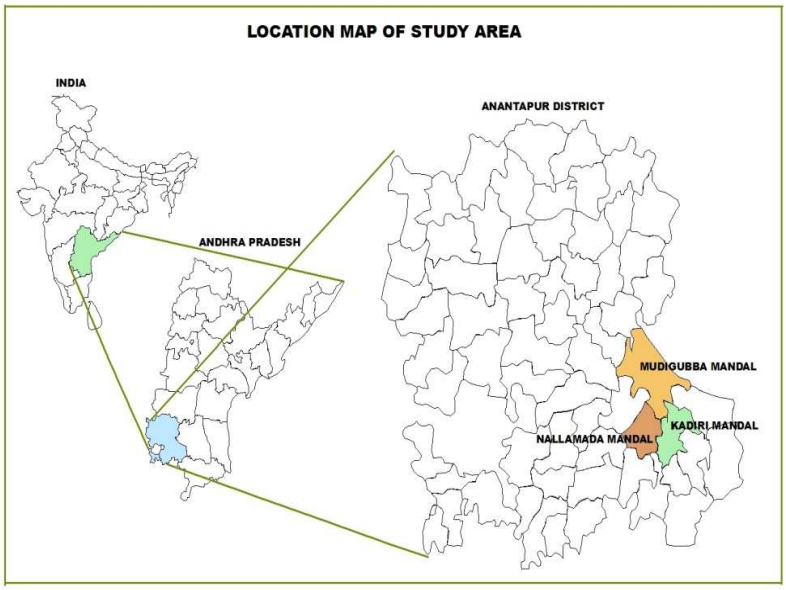

Figure 1: Location map of the study area

MATERIALS AND METHODS

Hundred groundwater samples were collected from 50 different locations of the study area which includes Kadiri, Mudigubba, Nallamada revenue mandals of Anantapur District, Andhra Pradesh, during October-November 2010. Sample location map of the study area is shown in figure 3. The samples were collected from bore wells which were extensively used for drinking and other domestic purposes. The samples were collected in pre-cleaned and sterilized polyethylene bottles of two litre capacity. The depth of the bore wells varied between 250 and 700 feet. The groundwater samples were analyzed using APHA (1995) procedure, and suggested precautions were taken to avoid contamination. The various parameters determined were pH, EC (electrical conductivity), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), total alkalinity (TA), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), sulfate (SO_4^{2-}), Sodium (Na^+), potassium (K^+), Nitrate (NO_3^-) and Fluoride (F^-). pH and EC were determined by pH, conductivity meter, TDS by TDS meter, TH, Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^- and Cl^- were estimated by titrimetry, where as Na^+ and K^+ by flame photometry (Systronics-128). F^- Was estimated by using ion selective electrode (Orion 4 star ion meter, Model: pH/ISE). All the experimental were carried out in triplicate and the results were found reproducible with in a ± 3% error limit.

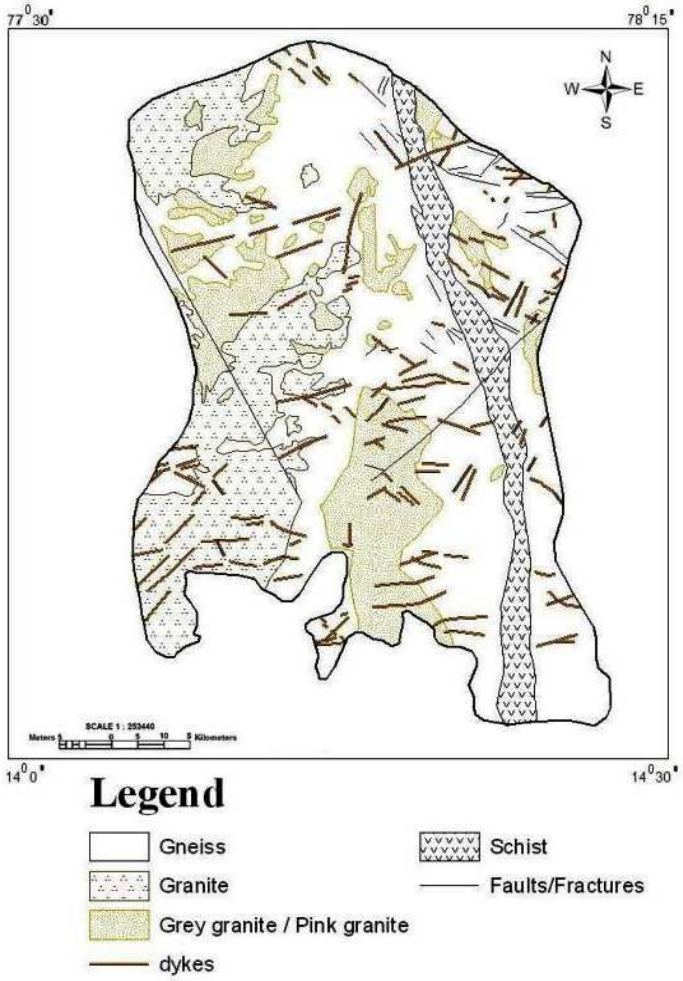

Figure 2: Geological map of the study area

RESULTS AND DISCUSSION

Various physicochemical parameters such as pH, electrical conductivity, total alkalinity, total hardness as well as calcium, magnesium, sodium, potassium, chloride, nitrate, carbonate, and bicarbonate were analyzed with the determination of fluoride concentrations. In general, the ground water had no colour, odour and turbidity except few samples. The pH varies from 7 to 8.6, with a mean of 8 indicating an alkaline condition which favours the solubility of fluoride-bearing minerals. In acidic medium (acidic pH), fluoride is adsorbed in clay; however, in alkaline medium it is desorbed, and thus alkaline pH is more favorable for fluoride dissolution activity. The electrical conductivity of the groundwater varies from 310 µs/cm to 2580 µs/cm. Elevated concentration of electrical conductivity may possibly be credited to high salinity and high mineral content. Total dissolved solids, a salinity indicator for the classification of groundwater, varies from 650 mg/l to 3280 mg/l in the study area. The bicarbonate content varies from 75 mg/l to 320 mg/l, and this high value indicates intense chemical weathering of the parent granite rock. The calcium content in the ground water of the study area varies from 70 mg/l to 360 mg/l and a sodium value of groundwater is varying from 280 mg/l to 850 mg/l. The calcium concentrations were lower than the sodium concentration (Table 1), which indicates the higher fluoride concentration in the ground water of the study area. A strong negative correlation between Ca^{2+} and F^- in the ground waters that contain Ca^{2+} in excess of that required for the solubility of fluoride minerals has been observed by many researchers. The concentrations of magnesium, chloride, sulfates were found to be 76, 211, 192 mg/l respectively, which were also considered to be above the permissible limit as prescribed by WHO. Excessive chlorides a bitter taste to water corrode steel and may cause cardio-vascular problems. The value of hardness varies from 246 mg/l to 1474 mg/l, around 80% of the samples were found to be very hard in nature. The high value of total hardness in supply water may cause corrosion of pipes, resulting in the pressure of certain heavy metals such as cadmium, copper, lead and zinc in drinking water. Total dissolved solids of the study area varies from 650 to 3280 mg/l. water with high total dissolved solids usually are lesser palatable and may bring in unfavorable physiological response, gastro-intestinal irritation. Enhanced nitrate concentration (20 mg/l to 110 mg/l), which was exceeding the permissible limits of 45 mg/l recommended by

the WHO, was noticed in most of the samples. It is well known that the nitrogenous fertilizers are one of the important sources for groundwater nitrate for the past two decades. Many investigators have reported that the contribution of nitrate from the fertilizer to the groundwater can vary from as little as 3 mg/l to as much as 1800 mg/l. Further nitrogenous materials are rare in geological system. High NO_3^- concentrations may cause a potential fatal blood condition known as methaemoglobinaemia, which especially affects infants.

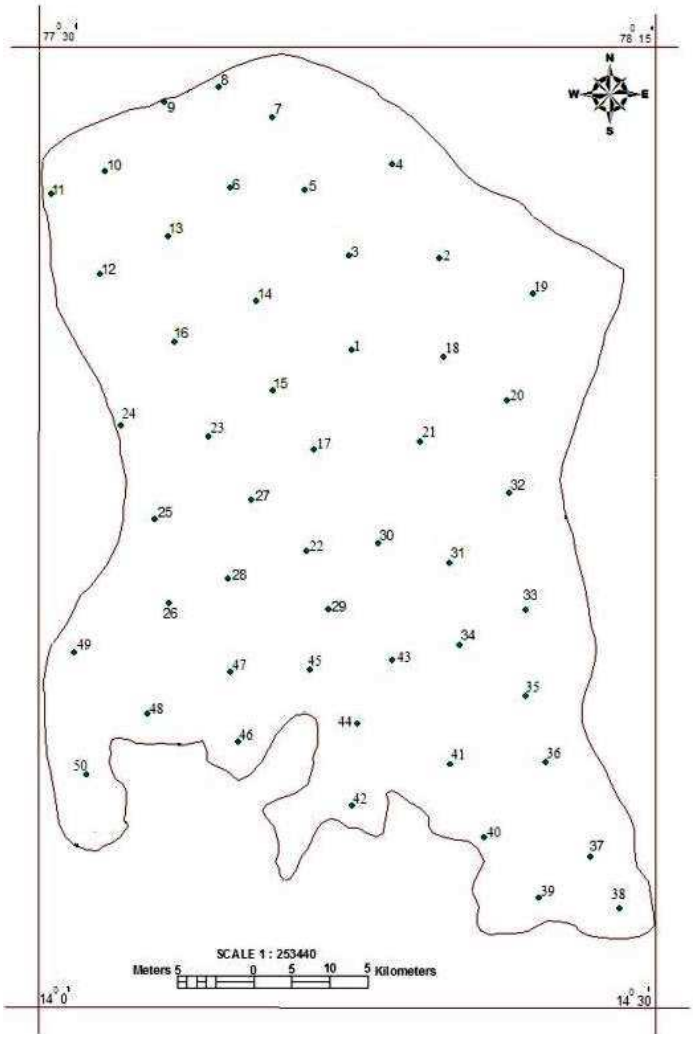

Figure 3: Sample Location map of the study area

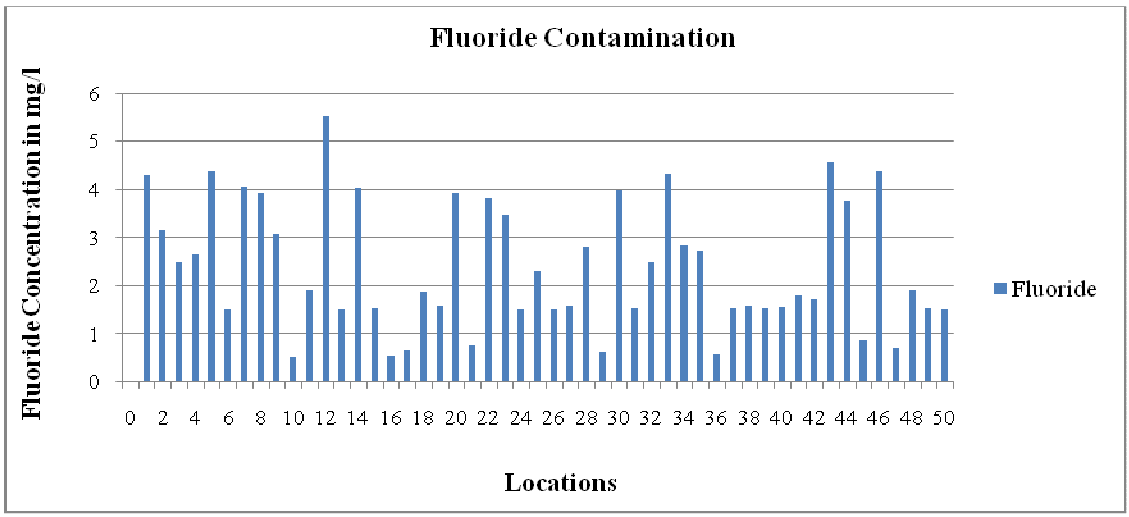

Figure 4: Fluoride concentration in groundwater of Anantapur district, Andhra Pradesh

Table 1: Analytical data of the chemical analyses of groundwater in Study area (in mg/l)

S.No	P^H	EC µS/cm	TDS mg/l	TH mg/l	Na^+ mg/l	K^+ mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	HCO_3^- mg/l	SO_4^{2-} mg/l	Cl^- mg/l	F^- mg/l	NO_3^- mg/l
1	7.4	420	1040	678	720	60	170	70	170	240	140	4.2	58
2	7.6	620	1050	650	780	68	180	60	160	210	170	3.1	55
3	7.3	510	2470	655	800	70	200	50	140	200	190	2.4	60
4	7.5	900	2450	346	850	72	70	58	150	140	170	2.6	68
5	8.3	850	2200	413	730	65	90	60	180	144	80	4.3	90
6	8.2	700	1800	496	840	40	110	62	210	160	82	1.5	92
7	8.3	350	1620	246	850	48	120	58	220	210	190	4.0	70
8	8.3	580	3020	505	780	50	130	50	230	220	95	3.9	30
9	8.3	310	1050	538	760	58	140	55	200	230	98	3.0	62
10	8.4	340	3050	596	820	60	150	64	210	280	110	0.5	45
11	7.2	360	2020	662	810	72	160	72	180	300	120	1.8	48
12	7.0	600	2310	728	840	50	200	70	160	95	130	5.5	56
13	8.0	680	1020	630	680	54	180	60	170	90	134	1.5	70
14	8.3	650	1080	621	700	80	190	68	130	98	220	4.0	72
15	8.4	460	1000	637	820	85	170	76	120	100	210	1.5	56
16	8.5	920	880	494	810	40	150	80	90	120	190	0.5	48
17	8.6	900	850	478	520	42	80	82	80	150	94	0.6	98
18	7.9	880	900	490	430	36	70	70	75	158	96	1.8	78
19	8.2	620	920	596	410	50	90	60	95	140	110	1.5	65
20	8.3	710	980	530	380	60	150	50	110	210	124	3.9	60
21	8.0	760	1000	539	350	58	140	45	140	95	128	0.7	20
22	8.6	630	1600	580	360	70	160	40	160	80	330	3.8	70
23	7.5	680	2000	639	310	72	180	42	150	210	410	3.4	100
24	7.6	700	2600	540	280	78	200	30	130	220	210	1.4	46
25	8.2	720	1500	398	450	70	120	38	138	98	180	2.2	56
26	8.6	740	1100	480	540	55	140	40	140	150	170	1.5	90
27	8.0	650	1800	539	530	50	160	45	145	160	130	1.5	97
28	7.6	670	1600	621	600	54	180	50	160	180	170	2.8	88
29	8.0	720	720	605	620	60	170	52	180	210	178	0.6	70
30	8.2	340	780	704	580	62	180	60	200	200	180	3.9	66
31	8.3	410	1100	721	610	70	190	65	190	190	210	1.5	20
32	8.0	1020	950	537	600	68	110	70	220	220	220	2.4	68
33	7.4	1080	920	562	630	52	120	72	150	170	240	4.3	49
34	7.6	780	650	528	570	40	100	75	140	160	160	2.8	56
35	7.2	800	680	478	580	30	70	80	160	180	72	2.7	70
36	8.3	2580	3000	1240	320	160	260	160	280	290	378	0.5	100
37	8.0	860	700	548	710	38	90	82	200	190	240	1.5	77
38	8.2	900	1010	594	700	54	110	84	210	220	260	1.5	56
39	8.6	720	1020	628	650	52	125	86	230	210	270	1.5	72
40	8.3	380	1220	648	840	50	130	90	210	140	290	1.5	54
41	8.0	400	1500	744	680	48	180	92	240	160	360	1.7	80
42	8.2	620	1620	835	700	45	200	98	250	220	310	1.7	80
43	7.6	650	1700	910	720	50	220	110	260	240	280	4.5	63
44	7.8	450	2000	926	680	70	210	120	264	250	210	3.7	33
45	7.6	520	2120	969	530	80	230	95	272	300	220	0.8	35
46	8.0	560	2140	1067	510	85	240	130	270	310	320	4.3	32
47	8.2	440	3100	1124	650	110	250	145	265	280	410	0.6	90
48	8.5	2030	3240	1322	380	170	270	180	300	270	480	1.8	110
49	8.0	1250	3100	1333	370	150	320	130	280	260	450	1.5	90
50	8.2	1210	3280	1474	380	180	360	140	320	250	380	1.5	78

Fluoride concentrations in the study area varied between 0.5 to 5.5 mg/l. Out of 50 villages samples analysed, only nine samples were observed below the permissible values of fluoride. All other samples analysed showed higher concentrations of fluoride compared to the prescribed permissible values. Maximum fluoride concentration (5.5 mg/l) was observed in the sample collected at Nallamada village, while the minimum value (0.5 mg/l) was observed in Reddipalli. Fluoride concentrations in groundwater of the study area are shown in figure 4. W.H.O has suggested maximum permissible limit of fluoride 1.5 mg/l in drinking water. About 90% of the samples of the study area are exceeding the permissible limits of fluoride.

Fluoride concentration in natural waters depends on several factors such as temperature, pH, presence or absence of ion complexes or precipitation of ions and colloids, solubility of fluorine-bearing minerals, anion exchange capacity of aquifer materials (OH) for F), the size and type of geological formations through which the water flows and the time water is in contact with a particular formation. Principally, controls are governed by climate, host rock composition and hydrogeology. Areas of semiarid climate, crystalline rocks and alkaline soils are mainly affected.

High fluoride concentrations groundwater suggest that favorable conditions exists for the dissolution of fluoride bearing minerals present in the granite and gneissic rocks in the study area. Fluoride bearing minerals occupy the joints, fractures, faults and vertical openings in the gneissic and granitic formations which are the oldest geological formations in Anantapur and have undergone maximum weathering. Granitic rocks are known to contain a relatively large proportion of fluorine minerals. Fluorite, the main mineral that controls the geochemistry of fluoride in most environments is found in significant amounts in granite, granite gneisses and pegmatite. Under the prevailing semi-arid climatic conditions, during weathering of granites, gneissic rocks, fluorine is released from apatite and biotite to the circulating alkaline groundwater. In the study area fluoride contamination is mainly a natural process i.e. leaching of fluorine bearing minerals, since no man-made pollution has been noticed.

CONCLUSION

The ground water which were taken from the various places of in and around southwestern part of Anantapur district were analyzed and the analysis reports that the water quality parameters like pH, EC, Cl^-, SO_4^{2-}, TDS, Ca^{2+}, Mg^{2+}, total hardness and suitability for drinking purpose with special reference to fluoride. Most of the water samples do not meet the water quality standards. Geological formation is found to be a basic cause for the higher concentration of fluoride in most of the sampling points. Probable sources of fluoride are weathering and leaching of F^- bearing minerals under the alkaline environment. Several reports on dental and skeletal manifestations of fluorosis are also reported in the study area, which shows that the population of the study area is at higher risk due to excessive fluoride intake. Further remedial measures for fluoride have to be carried out in the study area.

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