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NITRATE AND FLUORIDE CONTAMINATION IN GROUNDWATER OF TADIPATRI MANDAL, ANANTAPURAMU DISTRICT, ANDHRA PRADESH, INDIA

M. NAGARJUNA REDDY[1], P. ANANDHAN[1], T. LAKSHMI PRASAD[2]* AND B. MURALIDHARA REDDY[2]

[1]*Department of Earth Sciences, Annamalai University, Chidambaram 608 002, Tamil Nadu, India*
[2]*Department of Earth Sciences, Yogi Vemana University, Kadapa 516 005, A.P., India*

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ABSTRACT

Groundwater is a significant source of water in India for drinking, agriculture, and industry. The purpose of this study is to assess the quality of groundwater in Tadipatri Mandal of Anantapuramu District of Andhra Pradesh State, India, with a focus on fluoride contamination. Geologically the area consists of shales dolomites and limestone with mafic intrusives of the Chitravatri group of the Cuddapah super group, Penna is the major river in the study area. Thirty two water samples were gathered from the research area and tested for various physicochemical parameters pH, HCO_3^-, F^- and $N0_3^-$ as per the standards of WHO and IS. The alkaline pH (7.69-8.91 mg/l) and fluoride-bearing minerals are released into groundwater as a result of high bicarbonate levels which resulted in 96% of the sample locations exceeding the allowable levels of fluoride concentrations in the study area. Fluorides in groundwater sources range from 1.11 to 4.92 mg/l due to the region's dry climate, shale rocks, and inadequate clean water exchange due to periodic droughts. The presence of high nitrate content could be caused by intensive cultivation and in these areas, inorganic fertilisers are applied on a continuous basis which resulted in 21% of the sample locations exceeding the allowable limits of Nitrate concentrations in the research field ranging from 6.3 to 114 mg/l. After analyzing the study's data, it was determined that there is an immediate need to take preventative measures in this region to protect the population from fluorosis.

KEY WORDS : Tadipati Mandal, Anantapuramu District, Fluoride, Nitrate Concentration, Groundwater, India.

INTRODUCTION

Only about 2.5 percent of the world's water is safe to drink. The rest (over 97%) are found in the world's oceans as well as seas. Groundwater accounts for around thirteen percent of the just over 2.5% of fresh water, and is a vital source of drinking water over many people worldwide (Bachmat, 1994). For example, groundwater supplies drinking water to over fifty percent of the the globe's population. Many rural and small communities depend entirely on groundwater for drinking water (Canter, 1987).

The presence of fluoride in groundwater has sparked global concern because it has a significant impact on human health. High fluoride content in groundwater has emerged as one of the most serious health-related geo environmental issues in India (Bhagavan *et al.*, 2005). India contains nearly 12 million of the world's 85 million tonnes of fluoride deposits. As a result, fluorosis is endemic in 17 Indian states (UNICEF, 1999). Fluorosis is estimated to affect approximately 200 million people worldwide, spread across 25 countries. India and China, the world's two most populous countries, have been hit the hardest. Andhra Pradesh has reported abnormal fluoride levels in groundwater and human suffering (Ramamohana Rao 1982). According to estimates, fluoride poses a risk to 65% of India's villages (UNICEF, 1999). In India, between 60 and 65 million people consume groundwater tainted with fluoride, and 2.5- 3 million struggle with fluorosis (Athavale and Das, 1999). Children under nine should not drink water that has more than 2 mg/l of fluoride. Millions of people are suffering from dental and skeletal fluorosis due to fluoride contaminated water (Madhavan and Subramaniam, 2001).

Nitrate and fluoride contamination of groundwater is being extensively documented in various parts of the world. The main sources of this nitrate in groundwater are thought to be fertiliser and animal waste (Powlson *et al*., 2008). Nitrate concentrations above 45 mg/l have been linked to methemoglobinemia, gastric cancer, and birth defects (Mirvish, 1985). These two ions (fluoride and nitrate) have to be decreased in concentration to make the water drinkable.

STUDY AREA

The research area is in the eastern part of the Anantapuramu District and lies in the latitudes 14°31′56.316"N to 14°46′30.973"N longitudes 77°55′48.574"E to 78°8′6.424"E covering an extent of the total area of Tadipatri mandal is 361 km² with a mean elevation of 232m and is included in the survey of India topo sheet No. 57 E/16, F/13, I/4, J/1. The major rock types are granite, sandstone, dolomites and shale ranging from archeans to the Proterozoic Cuddapah sediments. Tadipatri is rich in cement grade limestone deposits (APSAC, District Survey Report, 2018). The three primary geomorphic features found in the study area are pediplains, dissected pediments, and denudational hills. A tributary of the Penna River runs the study area. The annual mean temperature in Tadipatri is 28.3 °C .The annual rainfall distribution reveals that the Tadipatri mandal receives an average rainfall of about 520 mm which is lowest in the State and second lowest in the Country (Anantapuramu). The major soil types in Tadipatri Mandal are black cotton soil, red loamy soil, and sandy loam soil. The nature of black cotton soil is expansive, with high swelling and shrinkage properties. When the black cotton soil is dry, it is hard, but when wet, it loses almost all of its stability. When it dries again, it has many cracks on its surface. When exposed to fluctuating moisture, expansive soil undergoes significant

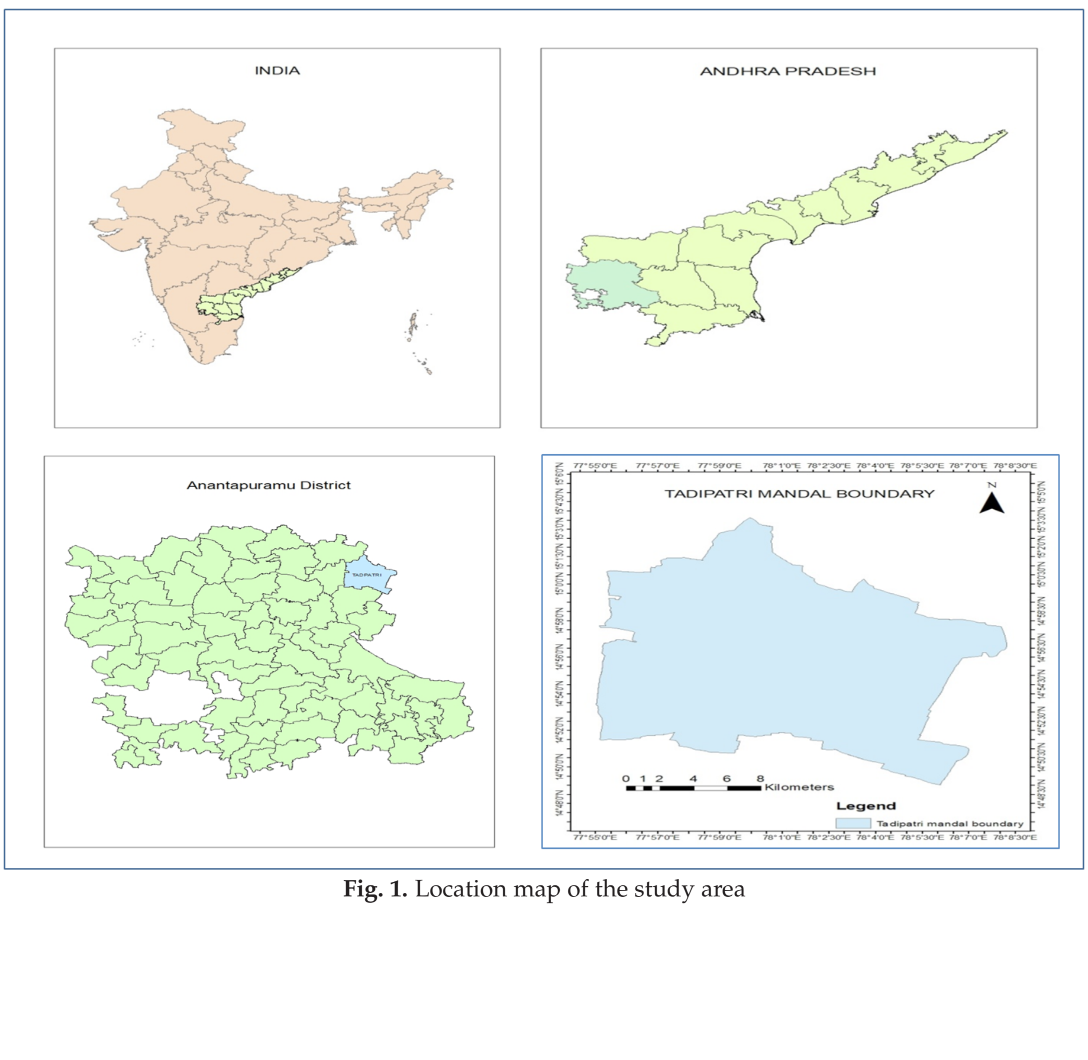

Fig. 1. Location map of the study area

volumetric change. Figures 1 and 2 depict the study area's location map and geology.

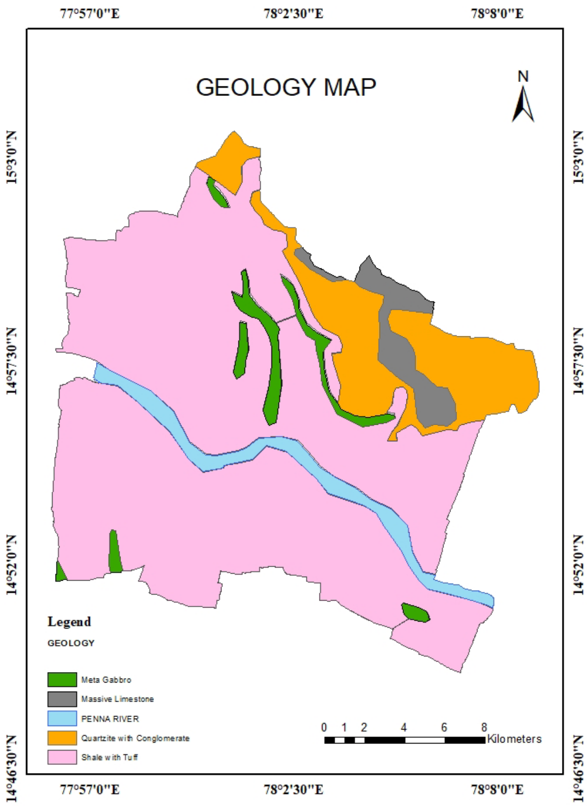

Fig. 2. Geology map of the study area

METHODOLOGY

During the post-monsoon season of 2022, 32 samples were taken in bore/dug wells in thirty-two villages in the research area. One-liter pre-sterilized and cleaned polyethylene bottles were used to gather samples. The sampling locations recorded by a handheld GPS device in the field presented in table 2. Figure-3 depicts the study area's sample location map. For sample collection, preservation, and analysis, standard methods (APHA, 2012) were followed. pH was measured during the sampling procedure itself. Fluoride (F^-) and Nitrate (NO_3^-) concentrations were determined using ion selective electrode (Orion 4 star ion meter, Model: pH/ISE) and Spectrophotometer. Table 1 shows the instruments and the calculation procedures applied to the chemical evaluation of groundwater samples.

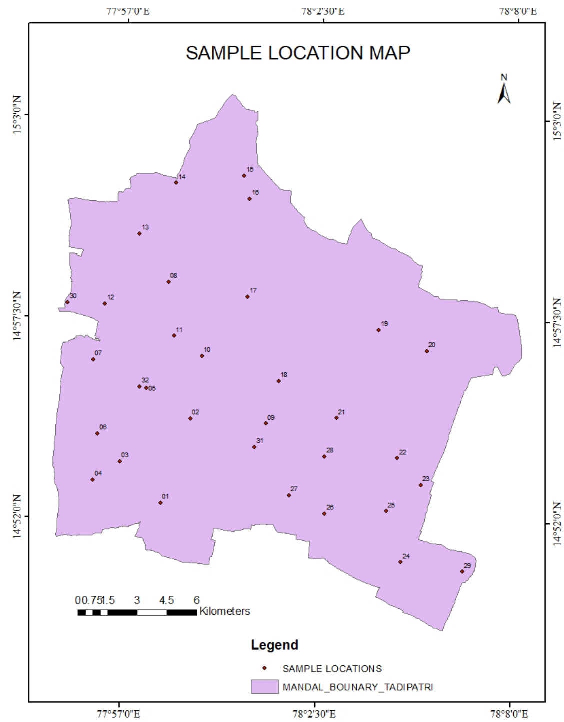

Fig. 3. Location of the study area with sampling points

RESULTS AND DISCUSSION

The groundwater was alkaline nature in the study area. Fluoride and nitrate levels in groundwater fluctuated enormously between villages. Table 3 shows the results of the chemical analysis of fluoride and nitrate concentrations. Groundwater samples of 32 locations (Table 1) in different villages namely, Diguvapalle, Nandalapadu, Peddapolamada, Yerragunta Palli, Chinnapolamada, Thathagari Palli, Komali, Gangadevipalle, Tadpatri(U), Chukkalur, Puliproddatur, Igudur, Brahmanapalle, Venkatampalle, Aiyyavari Palli, Bhogasamudram/ Bugga, Kaverisamudram, Sajjaladinne, Talaricheruvu, Uruchinthala, Alur, Velamakur, Bodaipalle, Vanganur, Veerapuram, Jambulapadu, Challavaripalle, Husenapuram, Bondaladinne,

Table 1. Chemical analysis of groundwater samples using instruments and calculation methods

Parameter	Method	Instruments	Unit	References
pH	pH Meter	pH Meter (Systronics MK VI)"	-	APHA(2012)
HCO_3^-	Volumetric	Titration	mg/L	APHA(2012)
NO_3^-	Turbidity	Spectrophotometer	mg/L	APHA(2012)
F^-	Ion selective electrode	Orion 4 star ion meter, Model: pH/ISE"	mg/L	APHA(2012)

Seetharampuram, Tadpatri(R), Pedda Padamala in Tadipatri Mandal in Anantapuramu District of Andhra Pradesh, India. Figures 3 and 6 depict fluoride and nitrate concentrations in groundwater in the study area. Table 4 displays a statistical summary of the study area's groundwater's chemical composition. During field survey, people in the villages complained about diseases of gastro – intestinal tract and bladder with symptoms of diarrhea and diuresis which may be caused by high fluoride and nitrate levels in the region. Indian Council of Medical Research (1975), has recommended 20 mg/l and 50 mg/l as desired and maximum allowable limits for nitrate and in view to prevent the diseases caused by high concentration of fluoride, I.C.M.R has suggested 1.0 mg/l as acceptable limit as well as the maximum allowable limit of 2.0 mg/l for fluoride in drinking water. Approximately more than 96% of the samples in the study area exceed the fluoride allowable limits, while more than 21% exceed the nitrate permissible limits.

Fluoride's effect on human health

Dental Fluorosis

Water with over 1.5 - 2.0 mg/l fluoride can do dental mottling, a type of dental fluorosis marked by opaque white patches in teeth. In the later phases of dental fluorosis, teeth indicate brown to black markings, then pitted of tooth surfaces. Dental fluorosis has been linked to crucial further dental costs alongside notable physiological stress in those who were impacted. Tooth fluorosis is widespread in fourteen Indian states as well as 150 thousand villages. The most severe states impacted are AP,

Table 2. Latitude and longitude locations and the chemical examination of collected groundwater samples in Tadipatri mandal, Anantapuramu district, Andhra Pradesh, India.

Sample No	Village Name	Latitude	Longitude
1	Diguvapalle	14^{0}15'25.72"N	77^{o}58'05.05"E
2	Nandalapadu	14^{0}54'44.37"N	77^{o}58'53.87"E
3	Peddapolamada	14^{0}53'32.90"N	77^{o}56'55.64"E
4	Yerragunta Palli	14^{0}53'1.6"N	77^{o}56'10.77"E
5	Chinnapolamada	14^{0}55'33.05"N	77^{o}57'38.76"E
6	Thathagari Palli	14^{0}54'18.22"N	77^{o}56'17.58"E
7	Komali	14^{0}56'19.51"N	77^{o}56'08.09"E
8	Gangadevipalle	14^{0}58'28.26"N	77^{o}58'13.77"E
9	Tadpatri(U)	14^{0}54'37.75"N	78^{o}01'01.31"E
10	Chukkalur	14^{0}56'27.10"N	77^{o}59'12.03"E
11	Puliproddatur	14^{0}56'59.91"N	77^{o}58'24.33"E
12	Igudur	14^{0}57'51.44"N	77^{o}56'26.99"E
13	Brahmanapalle	14^{0}59'47.14"N	77^{o}57'23.82"E
14	Venkatampalle	15^{0}01'10.86"N	77^{o}58'24.87"E
15	Aiyyavari Palli	15^{0}01'23.90"N	78^{o}00'19.51"E
16	Bhogasamudram/Bugga	15^{0}00'45.91"N	78^{o}00'29.01"E
17	Kaverisamudram	14^{0}58'05.43"N	78^{o}00'17.79"E
18	Sajjaladinne	14^{0}55'47.65"N	78^{o}01'21.98"E
19	Talaricheruvu	14^{0}57'14.03"N	78^{o}04'10.13"E
20	Uruchinthala	14^{0}56'40.02"N	78^{o}05'31.69"E
21	Alur	14^{0}54'48.34"N	78^{o}03'00.30"E
22	Velamakur	14^{0}53'43.59"N	78^{o}04'44.21"E
23	Bodaipalle	14^{0}52'59.94"N	78^{o}05'24.12"E
24	Vanganur	14^{0}50'53.13"N	78^{o}04'52.02"E
25	Veerapuram	14^{0}52'16.45"N	78^{o}04'26.16"E
26	Jambulapadu	14^{0}52'10.91"N	78^{o}02'42.72"E
27	Challavaripalle	14^{0}52'40.36"N	78^{o}01'42.05"E
28	Husenapuram	14^{0}53'45.21"N	78^{o}2'41.44"E
29	Bondaladinne	14^{0}50'38.76"N	78^{o}06'36.00"E
30	Seetharampuram	14^{0}57'48.64"N	77^{o}55'16.21"E
31	Tadpatri(R)	14^{0}53'58.71"N	78^{o}00'43.04"E
32	Pedda Padamala	14^{0}55'35.69"N	77^{o}57'27.43"E

Table 3. Fluoride and nitrate concentrations of the study area

S. No.	pH	Bicarbonate (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)
1	7.76	444	1.11	41.7
2	8.12	760	4.92	69
3	8.01	132	3.32	43.8
4	8.27	492	4.16	54.2
5	8.18	192	1.68	31.9
6	8.61	188	1.92	24.2
7	8.71	316	2.69	56.1
8	8.64	332	2.42	34.8
9	7.94	236	2.97	22.3
10	8.4	752	2.03	114
11	7.91	224	3.25	14.7
12	8.23	108	2.72	9.1
13	8.56	312	4.68	13.8
14	8.09	352	2.91	34.5
15	7.95	436	2.72	29.6
16	8.61	292	2.53	59.9
17	8.13	152	3.42	14.2
18	8.17	332	3.79	13.8
19	7.99	516	4.81	33.6
20	8.17	232	3.92	10.6
21	7.89	388	3.08	30.2
22	8.18	252	2.91	11.5
23	7.81	372	4.05	27.9
24	8.04	296	3.7	18.1
25	7.9	480	3.82	65.8
26	7.83	384	3.17	26.2
27	8.91	336	3.87	57.7
28	8.41	232	3.91	18.3
29	7.99	476	3.99	39.9
30	7.69	416	3.51	20.7
31	8.46	240	2.92	6.3
32	7.92	186	3.72	7.9

Bihar, Gujarat, MP, Punjab, Rajasthan, TN, and UP (Pillai and Stanley, 2002).

Bore wells and hand pumps are the primary sources of drinking water in Anantapuramu District's Tdipatri mandal. The high profile of natural fluoride concentration in groundwater is a major health issue in this village. Fluoride levels in drinking water are high, causing dental decay in addition to physiological changes. Figure 4 depicts the manifestation of dental fluorosis in Nandalapadu village, Tadipatri mandal.

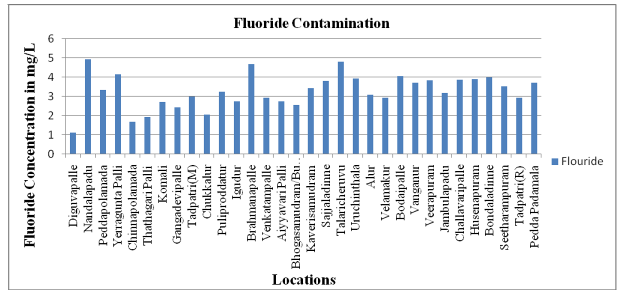

Fig. 3. Fluoride concentration in Tadipatri mandal, Anantapuramu district, Andhra Pradesh groundwater

Skeletal Fluorosis

Skeletal fluorosis may arise if fluoride levels in drinking water go over 4-8 mg/l, leading to raised bone mass, ligament calcifying, arthritis and muscles, stiffness in joints & rigidity, spinal column bending, as well as osteosclerosis (Teotia and Teotia 1992). Excess F- can cause hypocalcaemia (Sherlin and Verma, 2000). When fluoride levels in water go over 10 mg/l, it can cause crippling skeletal fluorosis (WHO 1984). Figure 5 depicts skeletal

Fig. 4. Fluorosis of the teeth in Nandalapadu village, Tadipatri mandal, Anantapuramu District, A.P.

Table 4. Statistical summary of the chemical composition of the study area's groundwater

Water quality parameters	Study area values		Mean	Median	Standard deviation Max accept Limit	WHO standards	Undesirable effect
	Minimum	Maximum					
Fluoride	1.11	4.92	3.285	3.175	0.889	0.5 -1.5	Fluorosis
Nitrate	6.3	114	33.0	28.75	23.191	0 -45	Methemoglobinemia

fluorosis with both legs affected and crippled from the village Talaricheruvu in Tadipatri mandal, at which the fluorine level is 4.92 mg/L.

Fig. 5. Skeletal Fluorosis in Talaricheruvu Village, Tadipatri mandal, Anantapuramu District, A.P.

Fluoride concentrations in Bodaipalli, Yerragunta Palli, Brahmanapalle, Talaricheruvu, and Nandalapadu villages exceed the 4.0 mg/l limit, with only one sample location having fluoride concentrations less than 1 mg/l. Because fluoride traces are necessary for healthy tooth and bone growth, this low fluoride can be used safely. Because of more is fluoride level of drinking water, an alarming number of cases of dental and skeletal fluorosis are emerged in this region.

Nitrate and Human Health

Drinking water with excessive nitrates has been related to methaemoglobinaemia or well water cyanosis in bottle-fed infants (Petakhove and Ivanove, 1970). Furthermore, there's circumstantial proof that amino acids and nitrite respond in human tissue to create carcinogenic nitrosamines, alongside the nitrite formed by decreased nitrates (Handa, 1983). While water nitrate limits exceed, infants who are under one year of age should be given low-nitrate water from different sources. The WHO (WHO 1984) has set the maximum allowable limit for nitrates in drinking water at 45 mg/l NO3. Because of the extensive use of fertilisers, nitrate (NO3) contamination of groundwater it is now a major threat to the environment in several remote parts of India along with a lot of emerging nations around the world Nitrate levels in groundwater have been rising over the last three decades (Mueller *et al*., 1995). A number of researchers from India and abroad have reported high nitrate concentrations in groundwater (Handa, 1983) and identified possible sources. In this context, a typical rural location in the Anantapuramu district of Andhra Pradesh, India, has been chosen for a systematic study to establish the baseline features of groundwater and the sources of contamination. Minimum value of nitrate concentration (6.3 mg/l) in groundwater is found in Tadipatri(R) and at Chukkalur (114 mg/l).

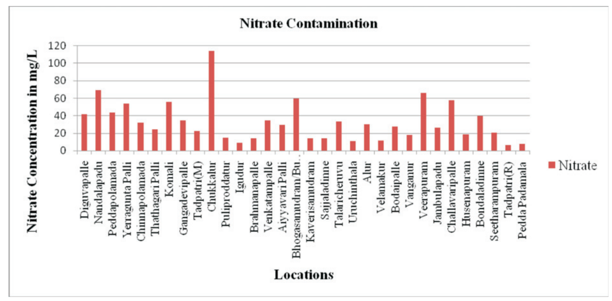

Fig. 6. Nitrate concentration in groundwater of Tadipatri mandal, Anantapuramu district, Andhra Pradesh.

The current study shows that nitrate concentrations in groundwater surpass 45 mg/l in several locations throughout the study area, with concentrations as high as 114 mg/l observed, despite W.H.O. suggesting a maximum allowable limit of 45 mg/l. The amount of nitrates in groundwater is utilized to detect pollution. As shown in Figure 6, the majority of groundwater samples drawn from bore wells or hand pumps contained nitrate levels ranging from 6.3 mg/l to 114 mg/l. These wells are located near agricultural land where inorganic fertilizers and pesticides are used in large amounts. Percolation of these chemicals pollutes the well water. The high nitrate level should be regarded as a serious issue for the future growth of drinking water. The detection of a high level of nitrate in these areas could be due to the continuous application of inorganic fertilizers.

CONCLUSION

Groundwater is the mainstay of drinking water for the inhabitants of Tadipatri Mandal in Anantapuramu district, Andhra Pradesh. From data on fluoride and nitrate levels in groundwater, the amount of fluoride is more instead of the safe level recommended by WHO and the ICMR. Fluorosis has emerged as a serious issue in the area. The alkaline pH (7.21-8.55 mg/l) and high HCO_3^- levels are accountable for the discharge of fluoride-containing minerals into the groundwater which resulted in 96% of the sample locations exceeding the allowable levels of fluoride concentrations in the research place. The region's arid climate, shale rocks, and low clean water exchange due to periodic droughts are the factors that cause a higher incidence of fluorides in groundwater sources. The presence of high nitrate content could be caused by intensive cultivation and in these areas, inorganic fertilisers are applied on a continuous due to these reasons the sample locations exceeding the allowable limits of Nitrate concentrations in the research field . The information that was provided can be used to create a sustainable plan for managing the groundwater resource and supplying drinkable water to the dependant population. Water quality is so crucial in these areas and causes health issues. Consequently, it is crucial to continuously examine the quality of the water. To protect future generations, it is essential to identify groundwater vulnerability zones and to take the appropriate precautions. This information can be used to create practical plans for enhancing the availability of potable water in rural areas as well as to support groundwater management decisions with scientific data.

REFERENCES

APHA, 2012. *Standard Methods for the Examination of Water and Waste Water*. 22nd Edition,

APSAC, 2018. District Survey Report - Department of Mines of geology, Anantapuramu district Andhra Pradesh.

Athavale, R.N. and Das, R.K. 1999. Beware! Fluorosis is zeroing in on you. *Down to Earth* (8): 24-25.

Bachmat, Y. 1994. Groundwater contamination and control, Marcel Dekker, Inc, New York.

Bhagavan, S.V.B.K. and Raghu, V. 2005. Utility of check dams in dilution of fluoride concentration in groundwater and the resultant analysis of blood serum and urine of villages, Anantapur District, Andhra Pradesh, India. *Environmental Geochemistry and Health*. 27: 97-108.

Canter, L.W. 1987. *Groundwater Quality Protection,* Lewis publications, Inc, Chelsea, MI.

Handa, B.K. 1883. Effect of festiliser on groundwater quality in India. In: symp.on groundwater Development -A perspective for the year 2000 A.D. imivevsly 06 Roorker, India.

Madhavan, N. and Subramanian, V. 2001. Fluoride concentration in river water of South Asia. *Current Science.* 80: 1312.

Mirvish, S.S. 1985. Gastric cancer and salivary nitrate and nitrite. *Nature*. 315: 461-462.

Mueller, D.N., Hamilton, P.A., Helsel, D.R., Hitt. K.J. and Ruddy, B.C. 1995. Nutrients in ground water and surface water of the united states - an analysis or data through 1992, water- resources investigations report 95-4031, United State Geological Survey, Denver.

Mueller, D.K. and Helsel D.R. Nudrienty in the nation's water - too much of a good thing? U.S. Geological Survey.

Petakove, N.J. andIvanove, A.V. 1970. Investigation of certain phychophysiological reactions in children suffering from methacmoglobinacmia *Hyg Sanit*. 35: 29-32.

Pillai, K.S. and Stanley. V.A. 2002. Implication of fluoride an endless uncertainty. *J. Environ. Biol*. 23: 81-87.

Powlson, D.S., Addiscott, T.M., Benjamin, N., Cassman, K.G., De kok, T.M. and Van Grinsven, 2008. When does nitrate become a risk for humans? *Journal of Environmental Quality*. 37: 291-295.

Ramamohana Rao, N.V. 1982. *Geochemical factors influencing the distribution of fluoride in rocks, soils and water resources of Nalgonda District, AP*. unpublished Ph.D Thesis, Osmania University, Hyderabad.

Ramam, P.K. and Murty, V.N. 1997. Geology of Andhra Pradesh Geological Society of India, India.

Sherlin, D.M.G. and Verma, R.J. 2000. Amelioration of fluoride induced hypocalcaemia by vitamins. *Human EXP. Toxicology*. 19: 632-634.

Teotia, S.P.S. and Teotia, M. 1992. Dental caries a disorder of high fluoride and low dietary calcium interactions. *Fluoride*. 27: 59-56.

UNICEF, States of the art report on the extent of fluoride in drinking water and the resulting endemicity in India, Report by fluorosis and rural development foundation for UNICEF, New Delhi, 1999.

WHO, Guidelines for drinking water quality, vol 12, Health criteria and other supporting information, World Health Organization, Geneva, 1984.

WHO (World Health Organization), Fluoride in drinking water, P.144 London, UK, IWA publishing, 2006.