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***Research paper***

# Studies on Environmental Geology and Health Hazards with Reference to Fluoride Rich Groundwater of Nalgonda District,Telangana State, India - a Remote Sensing and G.I.S. Approach.

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**Abstract**

In the area of study the quality and quantity of groundwater are below the normal standards. In this study spatial statistical methods have been used to demarcate highly polluted zones. Especially fluoride concentrated areas in Nalgonda district. Water quality, especially excess of fluoride concentration in groundwater, is a major concern in the study area. Levels of fluoride in groundwater are considerably greater than the permissible limit especially in Nalgonda district which is known for endemic fluorosis, which is caused by intake of high fluoride water is a slow, progressively, crippling malady affecting young and old, poor and rich, rural and urban population. The area under investigation lies in between the longitude $79^0$ 0'-$79^o$ 30' E and latitude $16^o$ 45'-$17^o$ 15' N. In as many as 1122 habitations in Ranga Reddy and Nalgonda districts, fluorosis is prevalent and they have fluoride content in excess of 1.5 mg/l drinking water. One such area where fluoride contamination in groundwater has been known for several years in parts of Nalgonda district of Telangana state. In this district, several thousands of people in various villages are suffering with advanced fluorosis. A number of studies carried out earlier established the extent of fluoride contamination in different villages. However, no attempt was made to study the spatial distribution of various quality parameters including fluoride in the groundwater of this area. With this background this investigation is planned and undertaken. The spatial variability of groundwater G.I.S techniques were presented. The fluoride variation with reference to other quality parameters was brought out. An attempt is being made to summarise and understand the factors that control the groundwater quality variation in the area of study. A detailed study on fluoride occurrence is taken up, mainly to see its relationship with various other parameters and the influence of hydrogeology and lineament pattern on fluoride occurrence.

***Keywords:*** *Groundwater, Fluoride, Remote sensing, Groundwater pollution and G.I.S., IRS 1C & ID.*

## 1. Introduction

Groundwater is vital for all living beings especially human beings. Groundwater is an important natural resource, especially in those parts of the country that don't have ample surface-water sources, such as the arid west of India.

The day to day increase in demand, availability, and cost factors are playing a major role on the utilisation of the groundwater for water supply needs of townships and rural areas. The availability of good quality groundwater is more important than the quantity. It is a well-known fact that clean water is absolutely essential for healthy living. Adequate supply of fresh and clean drinking water is a basic need for all human beings on the earth, yet it has been observed that millions of people worldwide are deprived of this. Fresh water resources all over the world are threatened not only by over exploitation and poor management, but also by ecological degradation. The main source of fresh water pollution can be attributed to discharge of untreated waste, dumping of industrial effluents, and runoff from agricultural fields.

An estimated 20 million people in India are affected by Fluorosis. Twelve states and Union Territory of Delhi have been declared as endemic for disease [1]. Geology, climate, and the choice of water source (apart from several social, technical and financial reasons) make Indian people vulnerable to high incidence of fluorosis.

In the literature it was reported that incidents of skeletal fluorosis are associated with fluoride concentration of drinking water as low as 3 mg/l to 4 mg/l which is at variance with reports from U.S.A, where no skeletal involvement and physical disability was seen, even at fluoride concentration up to was less than 8 mg/l. I selected similar type of area for conducting systematic laboratory investigations on incidence of fluorosis in relation to chemical characteristics of drinking water.

World Health Organisation [2] prescribes in drinking water fluoride concentration is 1.5 mg/l as the upper limit. However, prevalence of fluorosis is reported at much lower concentrations in many parts of the globe [3].

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Water is a major source of fluoride intake by men. The WHO [4] guidelines suggested that in areas with a warm climate, the optimal fluoride concentration in drinking water should remain below 1 mg/litre (1 ppm or part per million), while in cooler climates it could go up to 1.2 mg/litre. The differentiation derives from the fact that humans perspire more in hot weather and consequently drink more water. The upper permissible limit for fluoride in drinking water was set at 1.5 mg/litre, considered a threshold where the benefit of resistance to tooth decay did not yet shade into a significant risk of dental fluorosis [5]. (The WHO guideline value for fluoride in water is not universal. India, for example, lowered its permissible upper limit from 1.5 ppm to 1.0 ppm in 1998). In Kenya and South Africa, concentrations upto 25 ppm and in India, concentrations up to 28.0 mg/l have been reported [6].

The study area falls under semi-arid tract and receives scanty rainfall and has limited groundwater resources. It has a limited number of minor irrigation tanks, which rarely get filled.

### 1.1. Location

The area under investigation lies in between the longitude $79^0$ 0'-$79^o$ 30' E and latitude $16^o$ 45'-$17^o$ 15' N. The study area is located in and around Nalgonda town in Nalgonda district, Telangana state. For the detailed investigation of the occurrence, movement, quality and quantity of the groundwater an area of about 2880 sq.km. in Narkatpalli, Chityal, Katangur, Nakrekal etc. mandals have been selected. Moreover earlier it was reported that this area has been highly fluorinated. The location map shown in Fig.1.

## 2. Geology of the Study Area

Preparation of a geological map is the basic requirement to any kind of investigation on land.

Geologically the area of study forms a part of the Indian peninsular shield and comprises Archaean and Proterozoic formations characterised by the basement complex or the Peninsular gneissic complex rocks. The deposited in shallow basins and subsequently intruded by basic rocks are known as the Archaeans, which are the oldest formations. The gneisses and granites were subsequently intruded by dykes of dolerite and veins of pegmatite and quartz. The study area has been characterised by the rocks belonging to both Archaean and Proterozoic formations. The Proterozoic formations which are also known as Cuddapah formations. The present study area covers around 2880 Sq.kms. and stretches along the northern bank of the Krishna river. The study area is mostly rugged granitic plain which descends towards south-east,where the altitude of the hills ranges from 635 m (in the north-west) to 128 m (in the southeast). The geological map shown in Fig. 2.

The chosen area is underlain by crystalline rocks and consists of Peninsular gneissic complex i.e. pink and grey varieties of granites and granitic gneisses of Archaean age. The pink and grey granites are intruded by dolerite dykes and followed by injection of quartz, feldspar, pegmatite and epidote veins. Dolerite dykes mark the last period of igneous activity. There have also recent alluvial deposits in the area. They are confined to the valleys between the hill ranges as valley fill deposits and the flood plains of Hallia and Konagal rivers and also to the narrow thin patches along the streams.

The details of lithological variability of individual rock types including minor outcrops are presented though the entire area is characterised by granites and granite gneisses, there have been occurrence of minor variants within the granite gneiss like biotite gneisses, grey granites, pink granites, migmatites, pegmatites, quartz veins, aplites etc. Since these minor variants are not mappable hence are not shown the geological map presented.

## 3. Materials and Methods

The principle sources of fluoride available to the physiology of man area - 1) certain edible man and animals, 2) some species of vegetation, 3) dust, 4) certain industrial process and 5) rainwater. In the Nalgonda district there are no fluoride based Industries. Samples of rainwater also contains trace amount of fluoride always level is 0.01 mg/l. It is therefore, evident that fluoride must be derived from the weathering of fluoride based minerals in rocks and soils. Natarajan [7] of Survey of India reported excessive presence of fluoride minerals in porphyrite granite rocks in Sivannagudem fluorosis belt. He found that even some surface water (streams) originating from granite terrain contained unusually excessive concentration of fluoride range 2 mg/l - 7 mg/l. The present authors observed that water sample several areas in Nalgonda district.

In groundwater, the natural concentration of fluoride depends on the geological, chemical and physical characteristics of the aquifer, such as the porosity and acidity of the soil and rocks, the temperature, the action of other chemical elements, and the depth of wells. Because of the large number of variables, the fluoride concentrations in groundwater can range from well under 1 ppm to more than 35 ppm. [8].

In Telangana state, research has proved that fluorosis endemic areas are mostly lying in the places where the country rock is fluoride rich pink granite [3].

In recent times the interest in fluoride has greatly increased, owing to its importance in the fixation of phosphate in minerals like fluorapatite, and to the recognition of pathological conditions in man and animals, described as fluorosis by Ray [9].

The variation in groundwater quality with reference to various hydrogeological parameters including depth to water table, water level fluctuation have been analysed besides this the spatial variability of groundwater G.I.S techniques were presented. The fluoride variation with reference to other quality parameters was brought out. The database analysis and organisation has been summarised.

The multispectral satellite imageries has revolutionised the remote sensing activity. The characteristic parameters which play an important role in remote sensing for resources are spatial resolution, spectral band widths, repetitive coverage and radiometric sensitivity. In the present study, for visual interpretation different categories of imageries have been utilised from the false colour composite (FCC) (1:50,000) IRS 1C & ID. Interpretation study of remotely sensed data was attempted through logical processes in detection, identifying, classifying, measuring and evaluating the significance of physical and cultural objects, their patterns and spatial relationships [10].

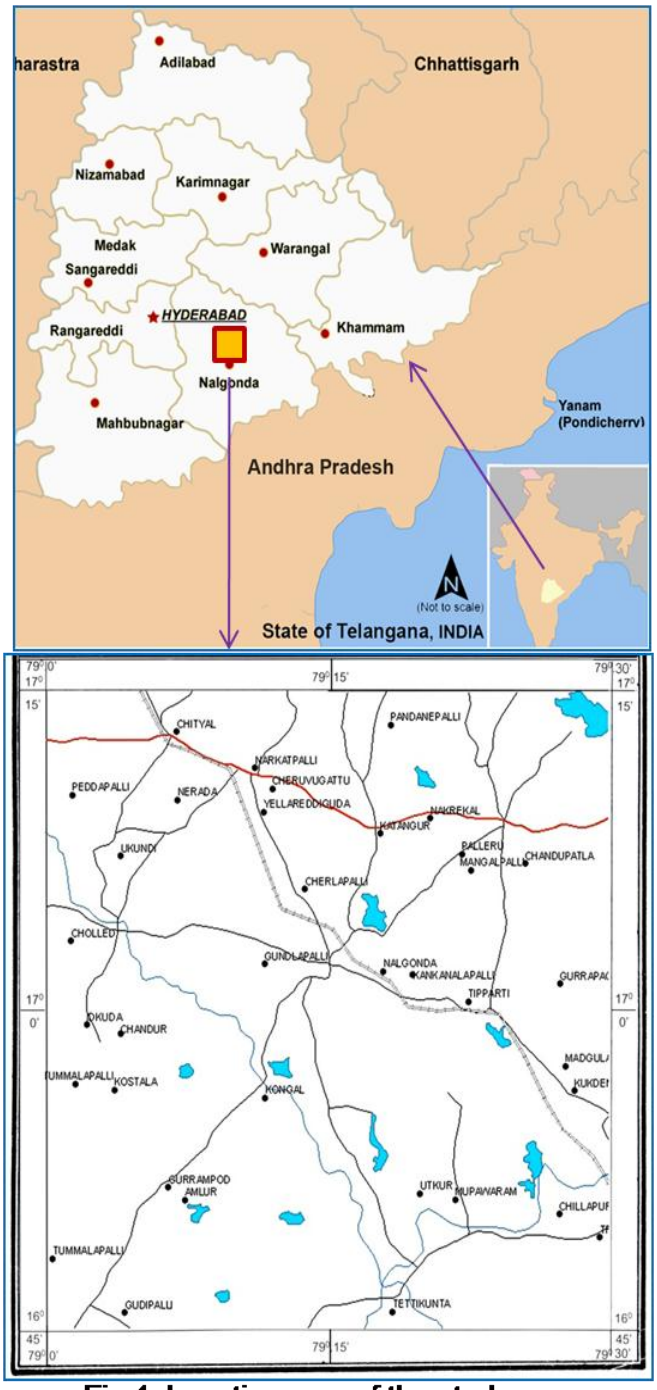


Fig.1: Location map of the study area

## 4. Results and discussion

### 4.1. Fluoride (F)

The area of study Fluoride variability having minimum of 0.20 mg/l to a maximum of 10.50 mg/l. The Fig. 3 presents the fluoride variability with reference to the depth of the wells. It is clearly inferred that F concentration and depth of the wells are proportional to each other.

As far as the distribution of fluoride with depth of the well is concerned that the highest average F value is recorded in the wells having depth range (> 18 m) is 3.64 mg/l whereas the lowest average of fluoride is registered in depth range (0-12 m) is 2.41 mg/l.

When specific villages are concerned highest F values are reported in the villages namely Amlur, Chandur, Pandanepalli and Yellareddiguda.

### 4.2. Spatial Variability

The G.I.S output map (Fig. 4) of fluoride concentration indicate that exceeding and highly exceeding levels F occur in the northern, northwestern parts of the study area. The F concentration is also showing some similarity with other parameters like K, Mg, Na and Cl. This is an important and significant observation and indicate that the source mineral or minerals which contributed these parameters must be the same. (Fig. 5A, 5B, 5 C).

To understand the complete picture of groundwater quality variability interms of pollution by all the parameters together the pollution zonation map of the study area has been prepared using the G.I.S technique. The map has been shown in Fig.6.

It is clear from this output map that moderate to high pollution characterizes northeastern and southwestern regions. Northern and northeastern parts of the district are characterised by high-level contamination of groundwater. southeastern part is comparatively less polluted. As far as fluoride is concerned, the output map (Fig. 4) shows that except some villages from eastern, central and southern portions, groundwater of rest of the area contain high fluoride. Important among such villages with high contamination of fluoride in groundwater are Yellareddiguda, Cheruvugattu, Chandur, Nakrekal, Kankanalapalli, Utkur, Chillapur, Cholled and Pandanepalli **(**Fig. 7). The levels of pollution in the study area has been shown in pollution zonation map besides comparing with National and International standards.

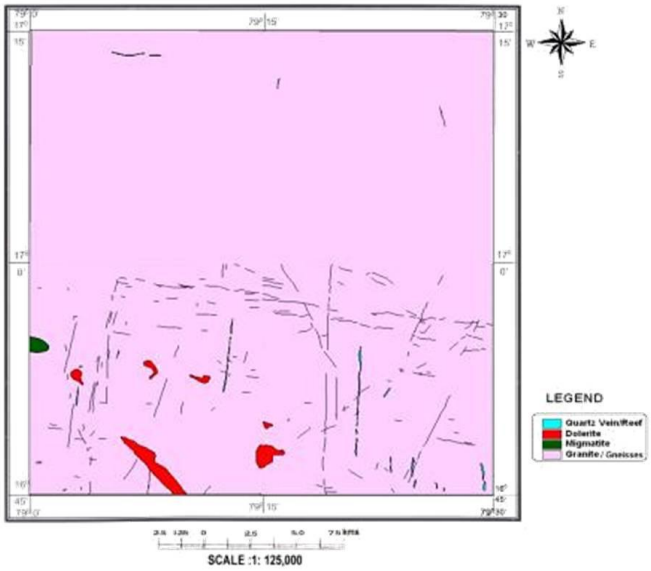


**Fig. 2 Geological map of the study area.**

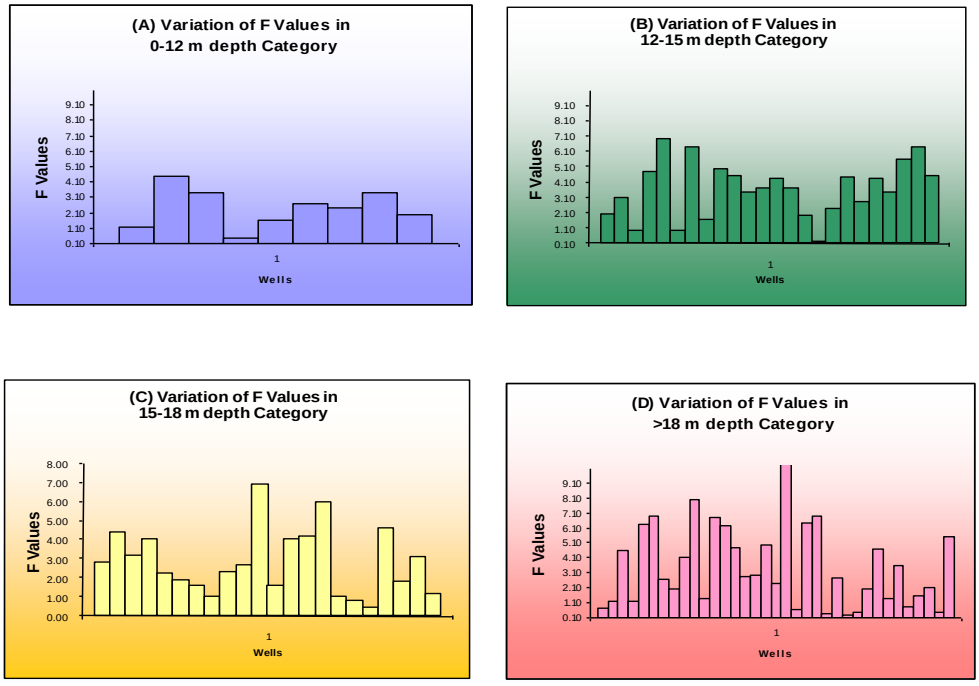


**Fig. 3** Variation of F values in different depth categories (A,B,C,D)

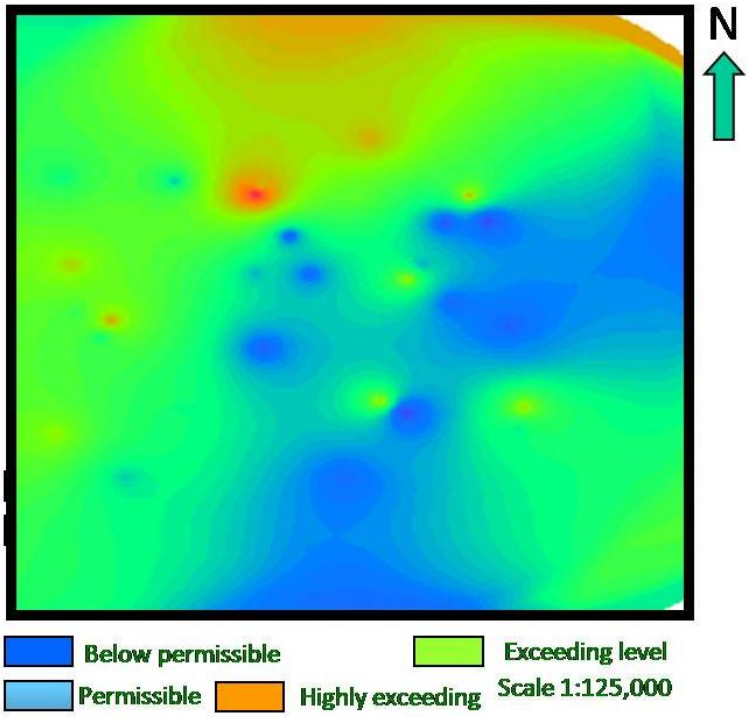


**Fig. 4 Spatial variability of Fluoride concentration**

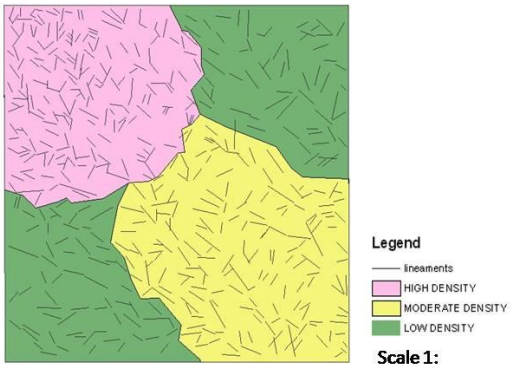


**Fig. 5A** Classification of study area based on lineament density.

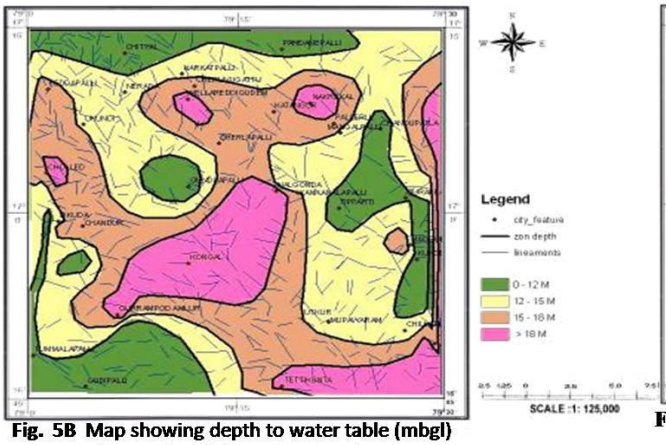


**Fig. 5B** Map showing depth to water table (mbgl) (Merged with lineament map).

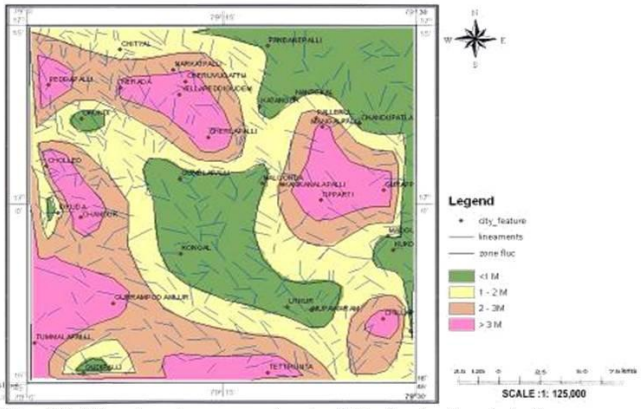


**Fig. 5C** Map showing seasonal water table fluctuation (mbgl) (Merged with lineament map).

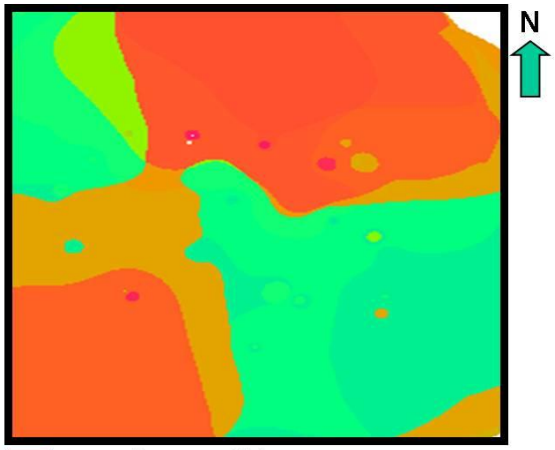


**Fig. 6** Groundwater Pollution zone map

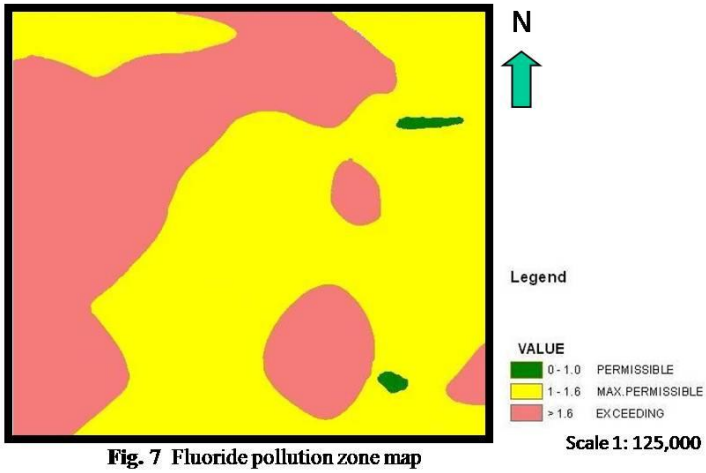


**Fig. 7** Fluoride pollution zone map

**Table 1** Groundwater quality compared with WHO and BIS standards

| Parameters | % Sample exceeding desirable limits | Effects when beyond the desirable limits |
|---|---|---|
| pH | within the range | The water supply system and/or mucous membrane |
| $Ca_2^-$ | 23 | Encrustation in water supply structure |
| TH | 81 | Encrustation in water supply structure |
| $Na^+$ | 12.12 | Heart diseases or Hypertension |
| $Mg_2^-$ | 79 | Encrustation in water supply structure |
| $F^-$ | 87 | Cause bone fluorosis |
| $Cl^-$ | 17 | Taste, corrosion and palatability are affected |
| $SO_4^{2-}$ | All are within the limits | - |
| $NO_3^-$ | All are within the limits | - |
| TDS | 94 | Palatability decreases and may cause gastroin-testinal irritation |

### 4.2.1. Fluoride (F)

The general range of fluoride content in a area of study is 0.2 mg/l to 10.2 mg/l. According to ICMR and ISI the permissible limits of fluoride concentration in the groundwater is 1.0 mg/l to 1.5 mg/l respectively. However, it is suggested that, if the fluoride content exceeds 1.5 mg/l, it is treated as undesirable for drinking (Fig.7).

In the study area some villages are showing higher concentrations of fluoride in the groundwater. The Table 2 gives the different villages list with reference to the standard levels of concentrations based on [11] and [5].

### 4.3. Effects of Fluoride on Human Health

Fluoride is beneficial to certain extent when present in concentrations of 0.8 mg/l -1.0 mg/l for calcification of dental enamel especially for the children below 8 years of age. But it causes dental fluorosis if present in excess of 1.5 mg/l and skeletal fluorosis beyond 3.0 mg/l if such water is consumed for about 8 to 10 years. As per WHO guidelines for drinking water quality and water technology mission of the Government of India, the permissible limit for fluoride in drinking water is 1.0 mg/l. It can be extended to 1.5 mg/l if there is no alternative source in the village [12].

Generally ingestion of water having a fluoride concentration above 1.5 mg/l -2.0 mg/l may lead to dental mottling, an early sign of dental fluorosis which is characterised by opaque white patches on teeth.

Skeletal fluorosis may occur when fluoride concentrations in drinking water exceed 4 mg/l -8 mg/l. Crippling skeletal fluorosis can occur when a water supply contains more than 10 mg/l [12].

In 1995, neurotoxicologist and former Director of toxicology at Forsyth Dental Center in Boston, Dr. Phyllis Mullenix published research showing that fluoride built up in the brains of animals when exposed to moderate levels. This caused the behaviour patterns of the animals adversely effected. A study published in Brain Research shows that rats drinking only 1 part per million fluoride (NaF) in water had histologic lesions in their brain similar to Alzheimer's disease and dementia. The Department of Health in New Jersey found that bone cancer in male children was between two and seven times greater in areas where water was fluoridated. U.S. Environmental Protection Agency (EPA) researchers confirmed the bone cancer-causing effects of fluoride at low levels in an animal model.

Fluoride gradually builds up in the bones and causes adverse changes to the bone structure. A toxicologist in the United King dom recently found that prenatal deaths in a fluoridated area was 15% higher than in neighbouring non-fluoridated areas.

**Table 2** Villages of fluoride incidence

| ISI and ICMR standards | Fluoride range | Village name | Fluoride average values |
|---|---|---|---|
| Exceeding maximum permissible limit (>1.6 mg/l) | 9-10 | Yellareddiguda | 9.8 |
| | 6-6.9 | Chandur | 6.03 |
| | 5-5.9 | Nakrekal | 5.7 |
| | | Pandanepalli | 5.6 |
| | | Utkur | 5.3 |
| | | Kankanalapalli | 5.3 |
| | | Chillapur | 5.2 |
| | | Cholled | 5.2 |
| | | Cheruvugattu | 5.02 |
| | 4-4.9 | Tummalapalli | 4.8 |
| | | Ukundi | 4.2 |
| | | Katangur | 4.2 |
| | 3-3.9 | Gurrampod | 3.62 |
| | | Idkuda | 3.61 |
| | | Peddapalli | 3.2 |
| | | Amlur | 3.13 |
| | | Kostala | 3.09 |
| | 1.6-2.9 | Gudipalli | 2.8 |
| | | Nerada | 2.6 |
| | | Gundlapalli | 2.54 |
| | | Gurrapagudem | 2.5 |
| | | Kukadem | 2.35 |
| | | Chityal | 2.3 |
| | | Tripuravaram | 2.02 |
| | | Tettikunta | 1.8 |
| Within highest desirable limit (1-1.5 mg/l) | 1-1.5 | Nalgonda | 1.5 |
| | | Cherlapalli | 1.26 |
| | | Konagal | 1.33 |
| | | Tipparti | 1.42 |
| | | Madugulapalli | 1.22 |
| Within permissible limit (0-1 mg/l) | 0-1 | Mupawaram | 0.3 |
| | | Chandupatla | 0.4 |
| | | Mangalapalli | 0.8 |

## 5. Conclusions

Geologically the area is marked by granite gneisses with local variants such as grey granites, pink granites, migmatites, aplites and younger basic intrusives like dolerites. The study revealed that the Geographical Information System (G.I.S.) has potential applicability in the groundwater evaluation especially to study the spatial variability of quality parameters of a given area. The results strongly and scientifically established the variability in quality in space. The fluoride concentration indicates that exceeding and highly exceeding levels of fluoride occur in northern and northwestern parts of the study area. The striking observation is the F concentration is also showing exact distribution pattern with

parameters like K, Mg, Na and Cl. This indirectly suggests the F derivation from the source mineral or minerals rich in K, Na, Mg and Cl. The extensive granitisation of the area might have contributed minerals of metasomatic origin rich in chlorine, fluorine besides potassium, sodium etc. which might have contributed the source minerals of these variables. The fluoride concentration has shown no difference in wells when studied with reference to time, in other words the fluoride concentration has no temporal variation. From the pollution zonation map it is very clear that moderate to high zonation pollution characterise northeastern and southwestern regions. northern and northeastern parts of the district are characterised by high-level contamination of groundwater. Southeastern part is comparatively less polluted. As far as fluoride is concerned, the output map (Fig. 4) shows that except some villages from eastern, central and southern portions, groundwater of rest of the area contain high fluoride. Important among such villages with high contamination of fluoride in groundwater are Yellareddiguda, Cheruvugattu, Chandur, Nakrekal, Kankanalapalli, Utkur, Chillapur, Cholled and Pandanepalli. As per I.C.M.R and I.S.I standards the villages Cheruvugattu, Idkuda and Amlur are in Exceeding maximum permissible (> 1.5 mg/l) limits. Where as the villages Nalgonda, Cherlapalli and Kostala are in within Permissible (0 to 1 mg/l) limits. And as the villages Chityal, Cheruvugattu, Pandanepalli, Gurrampod, Gurrapagudem, Chandur, Utkur, Chillapur, Madugulapalli and Tettikunta are within Highest desirable (1 to 1.5 mg/l) limits. As per the I.C.M.R and I.S.I standards the highly polluted villages are Yellareddiguda, Chandur, Nakrekal, Pandanepalli, Utkur, Kankanalapalli, Chillapur, Cholled, Cheruvugattu, Tummalapalli, Ukundi, Katangur, Gurrampod, Idkuda, Peddapalli, Amlur, Kostala, Gudipalli, Nerada, Gundlapalli, Gurrapagudem, Kukadem, Chityal, Tripuravaram and Tettikunta. As per the I.C.M.R and I.S.I standards the moderately polluted villages are Nalgonda, Cherlapalli, Konagal, Tipparti and Madugulapalli.

As per the I.C.M.R and I.S.I standards the low polluted villages are Mupawaram, Chandupatla and Mangalapalli. The fluoride contamination resulted extensive human suffering and disease. The people of study area are effected by fluoride related diseases like Skeletal fluorosis, Dental fluorosis etc. Especially, the incidence of these deformities occur in villages like Yellareddiguda, Chandur, Nakrekal, Pandanepalli, Utkur, Kankanalapalli, Chillapur, Cholled and Cheruvugattu.

## Acknowledgement

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