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Research paper

Integration of Geology, Hydrogeology and Geomorphology for Groundwater Occurrence in A Hard Rock Region from Parts of Nalgonda District, Telangana State, India, Using Remote Sensing and G.I.S Techniques

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Abstract

The study area is located in and around Nalgonda town in Nalgonda district, Telangana state. For the detailed investigation of the groundwater condition of a part of this district and covers an area of about 2880 sq.km. in Narkatpalli, Chityal, Katangur, Nakrekal etc. mandals have been selected. Survey of India toposheets on 56 0/4, 0/8, P/1, P/5, Scale - 1: 50,000, IRS ID LISS III satellite imagery using remote sensing and G.I.S. techniques. A detailed study is carried out by classifying the wells into four categories. The groundwater regime with reference to depth water table fluctuation has been evaluated in the study area. The deeper wells mainly occur or observed to occur in the central and southeastern parts of the study area whereas the shallow wells are confined to northern, eastern and southeastern parts of the study area. Also the drainage pattern is observed as medium to coarse textured and dendritic to subdendritic type, which is characteristic of hard rock terrain and develops in regions of homogeneity. The field data provides the information about the depth to water table, and fluctuation of the groundwater. The best suitable areas identified were mainly in shallow valley fill is mostly composed of sandy material, which are generally good to excellent of groundwater prospects. Most of the area posed good groundwater recharge capacity. Based on these studies on lineament density map of the entire study area has been prepared indicating areas of high, moderate and low density lineaments. The important observation is that the deeper wells are having low fluctuation whereas the shallow wells are characterised by high fluctuation and high density lineaments. To study the hydrogeological conditions in the area, field investigations were carried out and 94 wells were inventoried. Groundwater occurs in the study area under water table and semi-confined conditions limited to weathered and fractured zones. The zone of weathering ranges from 0 m (near inselbergs) to 17 m. The joints and fractures, which act as conduits for the movement of groundwater are responsible for the good yield of water from the wells.

Keywords: *Hydrogeology; Geology; Groundwater; Remote sensing and G.I.S.*

1. Introduction

Groundwater forms a very little quantity when compared to the total water available on the earth. It 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.
All life directly and indirectly depends on water. So the evolution of life became possible on earth because of the presence of liquid water. The total amount of water available in the hydrosphere is 1386 M.C.M. Out of this, fresh water constitutes 2.5%. The groundwater constitutes 29.9% of the fresh water, of which 0.9% exists in the form of soil moisture, swamp water, perma frost [1].

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. 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. Water quality, especially excess of fluoride concentration in groundwater, is a major concern in the study area. 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.

1.2. 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 and quantity of the groundwater an area of about 2880 sq.km. in Narkatpalli, Chityal, Katangur, Nakrekal etc. mandals have been selected. The location map of the study area is shown in Fig.1.

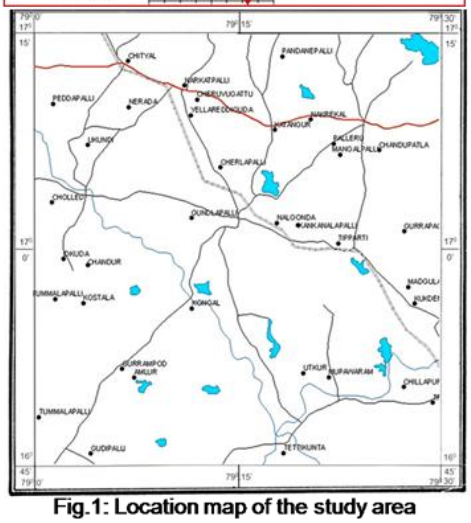

Fig.1: Location map of the study area

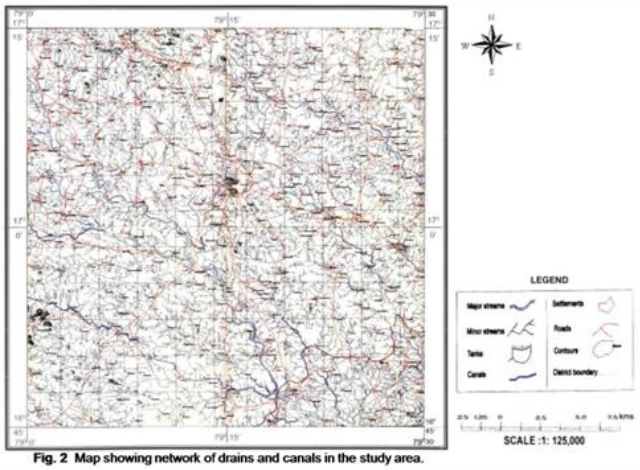

Fig. 2 Map showing network of drains and canals in the study area.

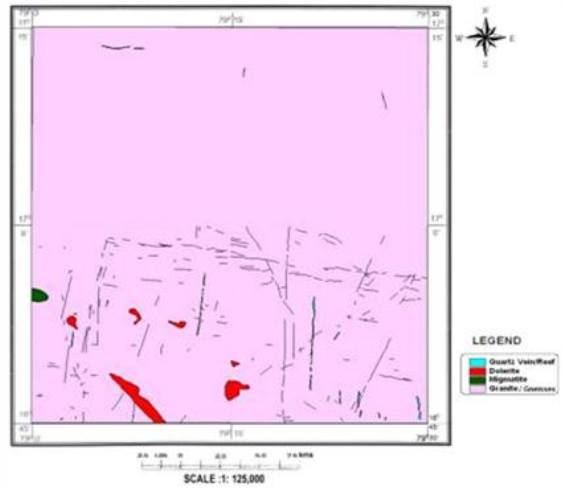

Fig. 3 Geological map of the study area.

Table 1 General geological succession of Nalgonda district

Age	Super group	Group	Lithology
Recent to Sub recent			Soil and Alluvium
Proterozoic	Kurnool	Jammalamadugu	Nargi limestones and shales
		Banaganapalli	Quartzites and conglomerates
		----------Unconformity----------	
	Cuddapah	Krishna	Srisailam quartzites and shales
		----------Unconformity----------	
	Younger intrusives		Quartz reefs, dolerites, pegmatites, quartz veins, pink granites and other ultra basics
Archaeans			
	Dharwar		Chlorite, hornblende schists and granulites
	Peninsular Gneissic complex		Grey granites, gneisses and migmatites
	Older metamorphics		Biotite schists Pyroxenites and amphibolites

1.3. Drainage

There are no perennial streams in the study area. The Palleru river, which is ephemeral in nature, drains from northwest to southeast traversing through the area. Many 1st to 3rd order streams are joining to the main river course. The drainage is medium to coarse textured and dendritic to sub dendritic type, which is characteristic of hard rock terrain and develops in regions of homogeneity [2]. The drainage is mostly structurally controlled and draining through the joints and fractures. The drainage is mainly from northwest to southeast. The shallow valley fill material, mainly sandy in nature underlies the river bed and hence forms very good media for infiltration of rain water to recharge the aquifer. The drainage map shown in the Fig. 2.

2. Geology of the Study Area

Geologically the study area 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 oldest known geological formations are the Archaeans which are deposited in shallow basins and subsequently intruded by basic rocks. The gneisses and granites were subsequently intruded by dykes of dolerite and veins of pegmatite and quartz, Fig. 3 shows the geological map of the study area

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).

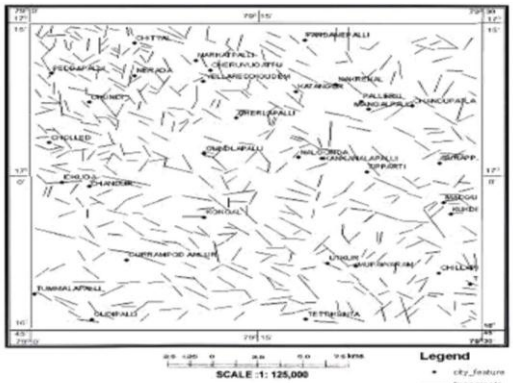

Fig. 4 Map showing lineaments of the study area.

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 stratigraphic succession of these rocks is shown in Table 1, [3].

2.1. Stratigraphic succession

The greater part of the area occupied by the Peninsular gneissic complex is of Archaean age. A generalised succession can be described as follows

3. Materials and Methods

3.1. Hydrogeology

The groundwater occurrence is dependent upon various factors including the lithology, geomorphology, rainfall, drainage etc. The movement of groundwater through crystalline rocks is one of the least predictable phenomena in all of groundwater science, because the porosity of these rocks, is very low and the permeability is usually controlled by an irregular network of streams. Since these Archaean group of rocks are practically devoid of primary porosity, the occurrence and movement of groundwater are mainly controlled by the nature, degree and depth of weathering and influenced by the presence of secondary structures like fractures, joints etc. When fractures control the permeability of the rock, the permeability will be anisotropic, with higher conductivity parallel to prominent fracture sets. The permeability of a fracture is controlled by its aperture and smoothness, properties that are near impossible to measure at the depth [4].

3.2. Nature of Aquifer

The groundwater condition of the aquifers which are existing in the study area have been evaluated with respect to the depth to water table and groundwater fluctuation. The data presented is mainly from well inventory studies.

3.3. Area of Peninsular Gneissic Complex (Granites and Gneisses)

Geomorphologically these areas come under the unit of shallow weathered buried pediplain and moderately weathered buried pediplain. Groundwater conditions in Peninsular gneissic complex (granites and gneisses) of the study area is indicated as depth to water table and seasonal fluctuations.

These areas of Peninsular gneissic complex (granites and gneisses) are generally poor aquifers, yet they are suitable for construction of dug wells, dug cum bore wells and bore wells. Groundwater is exploited in this zone mainly by dug wells which are used for domestic purposes and a few wells are used for irrigation. Many of these wells are operated by electrical or oil engines with capacities in the range of 2.5 H.P to 5 H.P.

4. Results and discussion

4.1. Lineaments

The lineaments in the study area are present in different directions with different lengths. Fig.5 shows that the majority of lineaments having the trend N 20^0 W to E-W, with 52.94% of lineaments are found in this direction.

In the north eastern direction the major set of lineament trend N20^0E to E-W with 43.05% of lineaments are found in this direction. Apart from this some of the lineaments trends N-S direction i.e., 3% and E-W direction with 2%.
A map of the entire area of study has been drawn , indications areas of high, moderate and low density lineaments based on the studies on lineament density (Fig. 4).

4.2. Water table Configuration

The configuration of the water table in the study area has been inferred, using the data collected by measuring the groundwater level in 94 wells. The well locations have been shown in the Fig5, [3]..

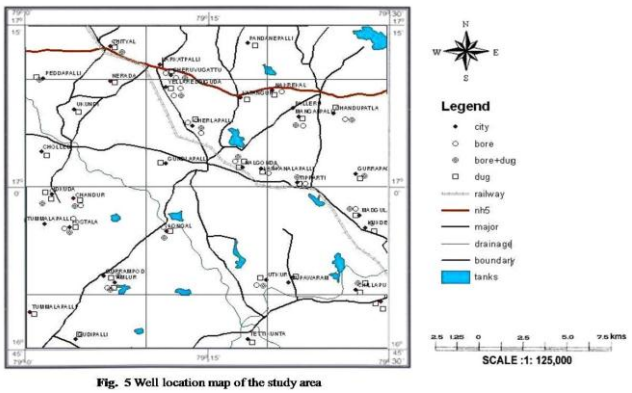

Fig. 5 Well location map of the study area

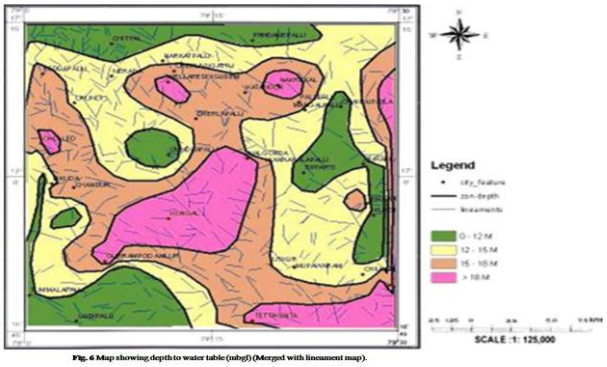

Fig. 6 Map showing depth to water table (mbgl) (Merged with lineament map).

The groundwater level varies from 0 mbgl to 19 mbgl. Based on this data, the study area has been classified into 4 categories as mentioned below (Fig.6).

Category	Configuration
I	wells with 0-12 mbgl
II	wells with 12-15 mbgl
III	wells with 15-18 mbgl
IV	wells with >18 mbgl

4.2.1. Category I (0 - 12 m)

The wells belonging to this category have been identified to be situated around the villages namely Chityal, Kostala, Amlur, Chandupatla, Tipparti, Kukadem, Gundlapalli. The details of the wells of this category have been shown in the Table 2. Majority of the wells belonging to this category are showing an average water table depth of 8.0 mbgl -12.0 mbgl

Geomorphologically all the wells are belonging to this category are located in all the places of the study area, which is characterized as undulating plain.

The lineament pattern with reference to the occurrence of these wells indicate majority of the wells are away from the lineament occurrence. The lack of lineament occurrence and high altitude of the area resulted a deep water table (Fig.. 7).

4.2.2. Category II (12 -15 m)

Table 2: Water table configuration

Category- I (0-12 m) Average depths				
Name of the Village	No.of wells	Dug wells	Depth to water level (pre monsoon)	Depth to water level (post monsoon)
Chityal	3	1	11.8	10.5
Kostala	3	1	12.0	10.5
Amlur	3	1	9.8	8.2
Chandupatla	3	1	12.0	11.0
Tipparti	3	1	11.8	9.9
Kukadem	2	1	9.0	8.0
Gundlapalli	2	1	11.0	10.0

In this category the wells having 12 mbgl to 15 mbgl depth have been grouped together. Majority of these wells are located in the villages namely Cheruvugattu, Nalgonda, Cherlapalli, Idkuda, Chandur, Mangalapalli, Kankanalapalli, Madugulapalli, Utkur, Chillapur, Tummalapalli, Gudipalli, Peddapalli, Ukundi, Gurrapagudem, Mupawaram, Katangur, Nerada and Pandanepalli. Majority of the wells are showing the depth to water level average range 10.9 mbgl to 15 mbgl. The data for this category is shown in Table 3.

Geomorphologically this category of wells also confined to the plain areas and majority of wells are located in all the places of the study area of the undulating areas.

The study of lineament pattern of this area, shows the fact that the lineament network has much influence on the groundwater occurrence and indicate that the lineaments have enhanced the chance of groundwater occurrence at much shallow levels, besides their influence on the formation of weathered and semi weathered zones, for aquifer localisation in the subsurface (Fig.8).

4.2.3. Category III (15 - 18 m)

In this category, wells belonging to 15 mbgl to 18 mbgl have been grouped together. These wells are noted to occur around the villages namely Yellareddiguda, Gurrampod, Tripurawaram, Cholled, Tettikunta, Kankanalapalli, Cholled, Pandanepalli, Tettikunta, Tripurawaram and Kostala. The data Table 4 indicate that the majority of wells are having an average range of 14.3 mbgl to 18.0 mbgl. However, the number of dug wells in this category are very few (08) and majority of the wells are bore wells.

Table 3: Water table configuration

Category- II (12-15 m) Average depths				
Name of the Village	No.of wells	Dug wells	Depth to water level (pre monsoon)	Depth to water level (post monsoon)
Cheruvugattu	4	1	14.7	12.9
Nalgonda	4	1	13.2	12.1
Cherlapalli	4	1	15	13
Idkuda	4	1	12	11
Chandur	3	1	15	13
Mangalapalli	3	1	13.7	11.9
Kankanalapalli	3	1	14.5	12.9
Madugulapalli	3	1	15	14
Utkur	3	1	14.5	13.4
Chillapur	4	1	13	11
Chillapur	4	1	14.3	12.8
Tummalapalli	2	1	12.8	10.9
Gudipalli	2	1	12	11
Peddapalli	2	1	15	13
Ukundi	2	1	14	13
Gurrapagudem	3	1	12.8	10.9
Mupawaram	2	1	13	12
Katangur	2	1	15	14
Nerada	2	1	13.7	11.9
Pandanepalli	2	1	12.6	11.4

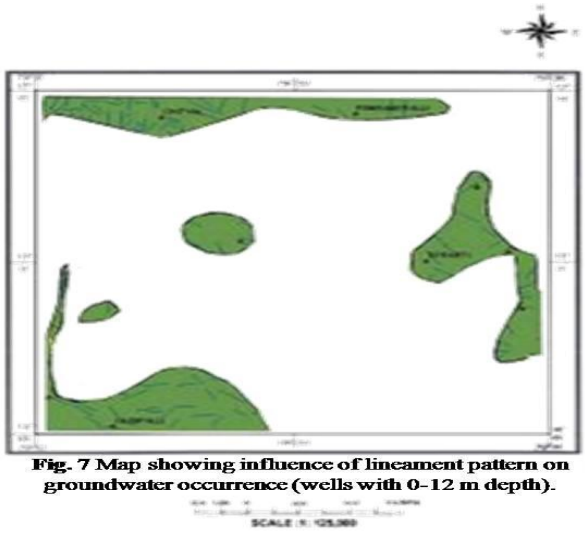

Fig. 7 Map showing influence of lineament pattern on groundwater occurrence (wells with 0-12 m depth).

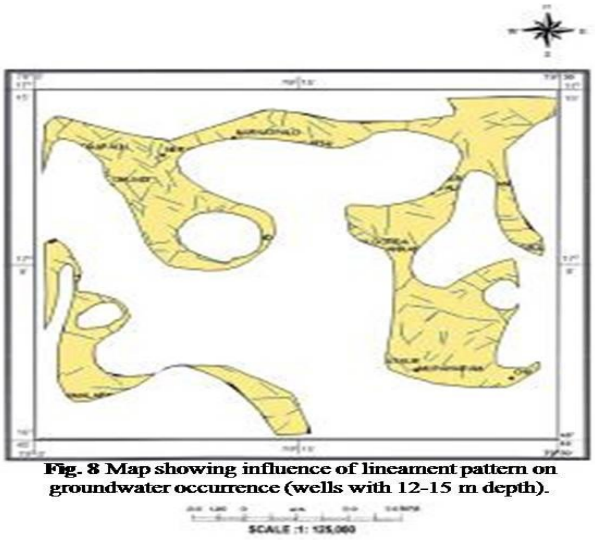

Fig. 8 Map showing influence of lineament pattern on groundwater occurrence (wells with 12-15 m depth).

Table 4: Water table configuration

Category- III (15-18 m) Average depths				
Name of the Village	No. of wells	Dug wells	Depth to water level (pre monsoon)	Depth to water level (post monsoon)
Yellareddiguda	4	1	17.8	15.9
Gurrampod	4	1	17.7	15.8
Tripurawaram	3	1	16.8	15.4
Cholled	2	1	17	15
Tettikunta	2	1	16.8	14.9
Kankanalapalli	3	1	17.5	14.3
Cholled	2	1	17	14.8
Pandanepalli	2	1	17.7	15.3
Tettikunta	2	1	18	17.2
Tripurawaram	3	1	16	15.8
Kostala	4	1	19	17.5

The formation of alluvium at some places are observed. Geomorphologically, the area can be categorised as undulating plain and the majority of wells are situated in the northern portion of study area.

The distribution of lineament pattern with reference to the location of wells of this category indicate that, the lineament occurrence in this zone has shown a decreasing trend when compared to the earlier category (Fig.9). This clearly confirm the observation that the groundwater configuration has been influenced by the lineament pattern, besides the other factors namely lithology and geomorphology.

4.2.4. Category IV (> 18m)

In this category the wells which are characterised by very deep water table (>18 mbgl). These deeper water table wells are located to occur around the villages namely Nalgonda, Konagal, Nakrekal, Tipparti, Idkuda, Chillapur, Cheruvugattu and Gurrampod. About 08 dug wells have been identified in this category and majority are bore wells. The data indicated in Table 5, and the average depth to water level range from 15.1 m to 19.0 m.

The location of these wells are around northern part. The lineament pattern indicates that, the occurrence of lineaments in this area belonging to this category is very rare. The occurrence of deep water levels can be explained by the lack of lineament pattern. The well locations are shown in the Fig.10.

4.3. Water table Fluctuation

Fluctuations of water table in the study area has been measured for 47 wells based on this data the wells have been classified into 4 categories. These fluctuations have been depicted in the Fig.11**.,** [3].

Category	Fluctuation
I	Ground water Fluctuation < 1 m
II	Ground water Fluctuation 1 – 2 m
III	Ground water Fluctuation 2 – 3 m
IV	Ground water Fluctuation > 3 m

4.3.1. Category I (< 1 m)

In this category about 10 wells have been identified. These wells are located in the villages namely Nalgonda, Idkuda, Konagal, Chandupatla, Kukadem, Gudipalli, Ukundi, Mupawaram, Gundlapalli and Katangur majority of these wells are dug wells. The data indicate most of the wells show average fluctuation in the range of 0 m to 01 m (Table 6).

The wells of this category have been identified mainly in the eastern, southern, southeastern regions

Geomorphologically, all these wells are mainly confined to the undulating plain with exception of very few wells.

The relationship between the lineament pattern and the positioning of wells confirm that the area has high density of lineaments. This aspect can also be realised in the Fig. 12.

4.3.2. Category II (1- 2 m)

In this category about 27 wells have been identified (1-2 m). The wells are situated in and around villages namely Chityal, Cheruvugattu, Yellareddiguda, Nalgonda, Cherlapalli, Kostala, Gurrampod, Amlur, Nakrekal, Mangalapalli, Kankanalapalli, Tipparti, Madugulapalli, Utkur, Tummalapalli, Peddapalli, Gurrapagudem, Tripurawaram, Nerada, Pandanepalli, Tettikunta, Idkuda, Chandur, Chillapur and Cholled. The average range of fluctuation in this category has been observed which is in the range of 1.1 m to 2.0 m Table 7.

Majority of the wells investigated, belong to this category are located in the central as well as northern regions of the

study area. Lithologically the rock types are mainly Peninsular gneissic complex.

Geomorphologically, majority of these wells are confined to the plains and a few wells are confined to undulating plain.

The lineament pattern in relation to the fluctuation indicated that the density of lineaments localised in this area is less, when compared to the earlier
category. However, majority of the lineaments of the earlier category are also extending into this category. In other words, these two categories can be called as a gradual transformation from a low fluctuation zone to the fluctuation upto 2 m. This aspect can also be realised from the Fig. 13.

4.3.3. Category III (2- 3 m)

In this category the wells having the fluctuation of groundwater table in the range of 2 m to 3 m have been grouped together. About 05 wells have been investigated, these wells are located in the villages namely Idkuda, Cholled, Chillapur, Pandanepalli and Nalgonda. These wells form very small number when compare to earlier two categories (Table 8).

Geomorphologically, the wells are located mainly in undulatory. The location of these wells with referene to the lineaments indicate that the lineaments have little or no influence on these areas, as shown in Fig. 14.

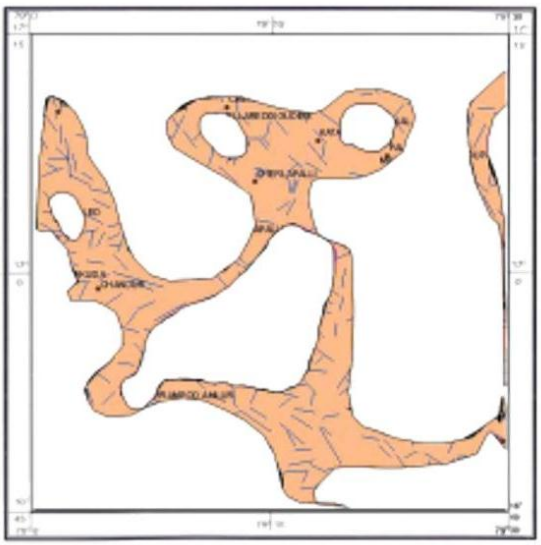

Fig. 9 Map showing influence of lineament pattern on groundwater occurrence (wells with 15-18 m depth).

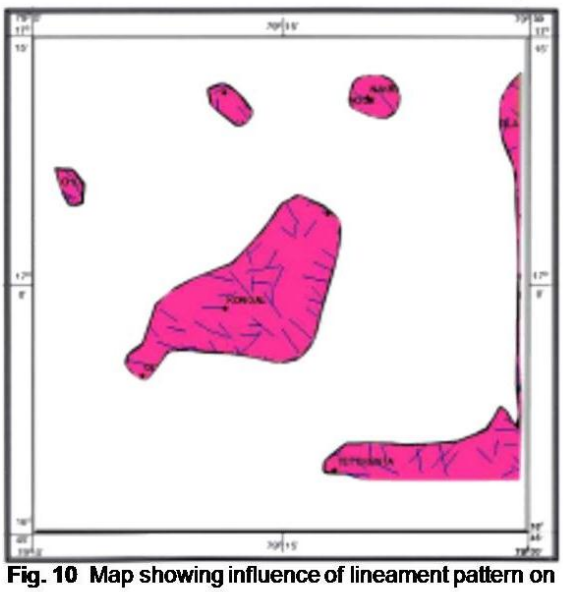

Fig. 10 Map showing influence of lineament pattern on groundwater occurrence (wells with >18 m depth).

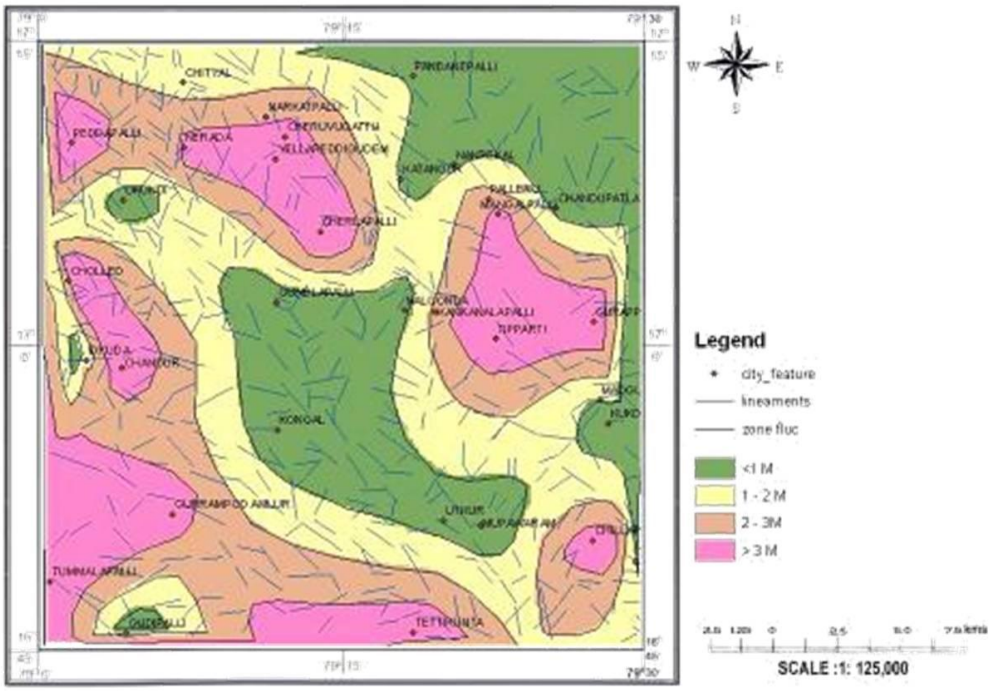

Fig. 11 Map showing seasonal water table fluctuation (mbgl) (Merged with lineament map).

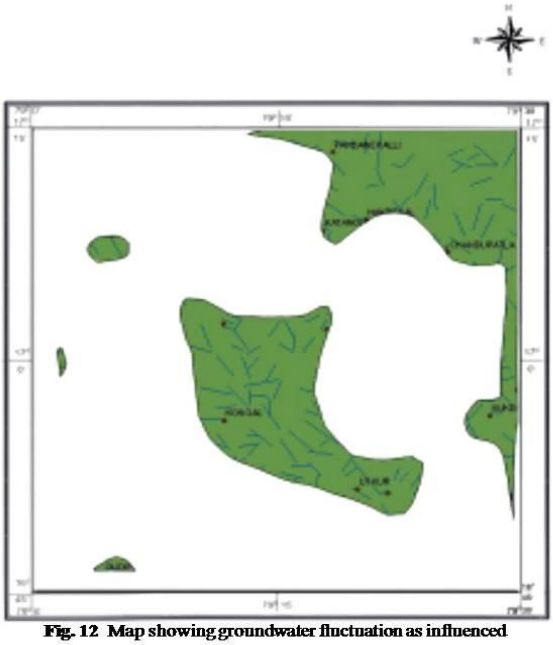

Fig. 12 Map showing groundwater fluctuation as influenced by lineament pattern (wells with < 1 m fluctuation).

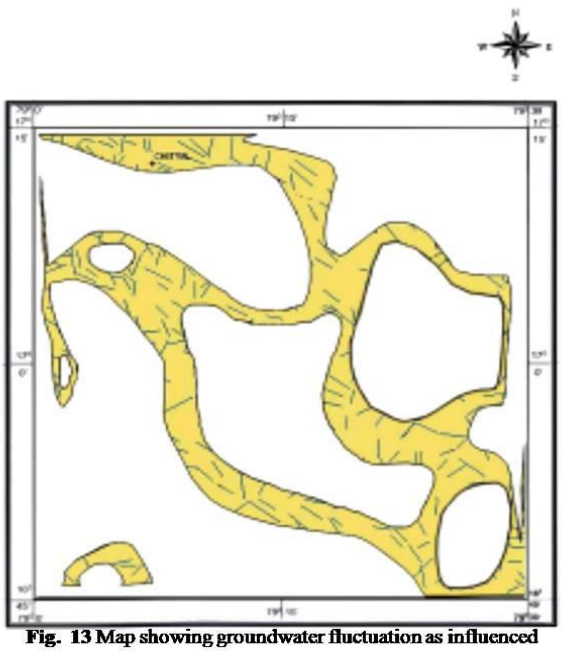

Fig. 13 Map showing groundwater fluctuation as influenced by lineament pattern (wells with 1-2 m fluctuation).

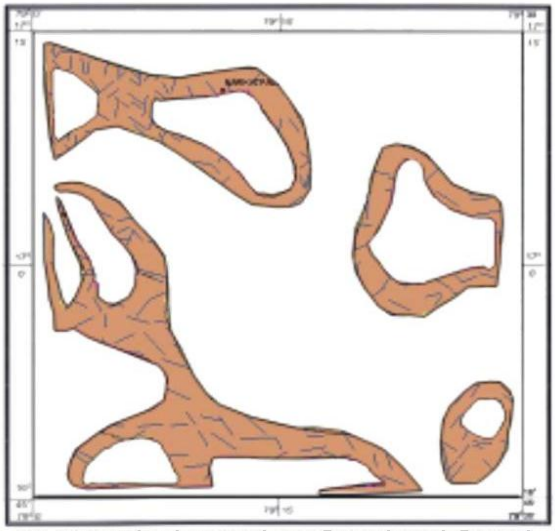

Fig. 14 Map showing groundwater fluctuation as influenced by lineament pattern (wells with 2-3 m fluctuation).

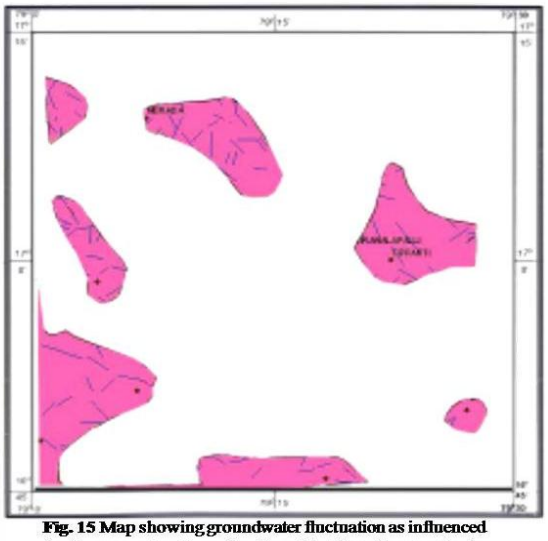

Fig. 15 Map showing groundwater fluctuation as influenced by lineament pattern (wells with >3 m fluctuation).

4.3.4. Category IV (> 3 m)

In this category the wells having very high fluctuation over of more than 3 m have been grouped together. However only 05 wells of this category were identified. They are located in the villages namely Tettikunta, Gurrampod, Tipparti, Kankanalapalli and Nerada (Table 9).

It is observed that the above mentioned areas are devoid of any lineament and so the wells are not influenced, as shown in Fig. 15.

It is interesting to observe that the areas having fluctuations from >1 m to 2 m (first two categories) predominate the study area. The wells in the areas belonging to these two categories seem to be in transitional (midway) form. Wells having fluctuations from 2 m to 3 m and more, are present adjacent to the above, showing inter-relationship with them. In other words they all belong to the same hydrogeological environment

Table 6 Water level fluctuation
Category – I (< 1 m) Average depths

Name of the village	No.of wells	Dug wells	Depth to water level (pre monsoon)	Depth to water level (post mon-soon)	Fluctuation
Nalgonda	4	1	19	18	1
Idkuda	4	1	12	11	1
Konagal	3	1	19	18	1
Chandupatla	3	1	12	11	1
Kukadem	2	1	9	8	1
Gudipalli	2	1	12	11	1
Ukundi	2	1	14	13	1
Mupawaram	2	1	13	12	1
Gundlapalli	2	1	11	10	1
Katangur	2	1	15	14	1

Table 7 Water level fluctuation Category – II (1-2 m) Average depths

Name of the village	No. of wells	Dug wells	Depth to water level (pre monsoon)	Depth to water level (post monsoon)	Fluctuation
Chityal	3	1	11.8	10.5	1.3
Cheruvugattu	4	1	14.7	12.9	1.8
Yellareddiguda	4	1	17.8	15.9	1.9
Nalgonda	4	2	13.2	12.1	1.1
Cherlapalli	4	1	15	13	2
Kostala	3	1	12	10.5	1.5
Gurrampod	4	1	17.7	15.8	1.9
Amlur	3	1	9.8	8.2	1.6
Nakrekal	2	1	18.6	17.4	1.2
Mangalapalli	3	1	13.7	11.9	1.8
Kankanalapalli	3	1	14.5	12.9	1.6
Tipparti	3	1	11.8	9.9	1.9
Madugulapalli	3	1	15.5	14.3	1.2
Utkur	3	1	14.5	13.4	1.1
Tummalapalli	2	1	12.8	10.9	1.9
Peddapalli	2	1	15	13	2.0
Gurrapagudem	3	1	12.8	10.9	1.9
Tripurawaram	3	1	17.8	16.4	1.4
Tripurawaram	3	1	15.8	14.6	1.2
Nerada	2	1	13.7	11.9	1.8
Pandanepalli	2	1	12.6	11.4	1.2
Tettikunta	2	1	16.8	14.9	1.9
Idkuda	4	1	18.2	16.7	1.5
Chandur	3	1	15.7	13.8	1.9
Chillapur	4	1	13	11	2.0
Chillapur	4	1	14.3	12.8	1.5
Cholled	2	1	17.0	15.0	2.0

Table 8 Water level fluctuation
Category – III (2-3m) Average depths

Name of the village	No.of wells	Dug wells	Depth to water level (pre monsoon)	Depth to water level (post monsoon)	Fluctuation
Idkuda	4	2	18.6	15.7	2.9
Cholled	2	1	17.0	14.8	2.2
Chillapur	4	2	18.3	16	2.3
Pandanepalli	2	1	17.7	15.3	2.4
Nalgonda	4	2	17.5	15.3	2.2

Table 9 Water level fluctuation
Category – IV (> 3 m) Average depths

Name of the village	No. of wells	Dug wells	Depth to water level (pre monsoon)	Depth to water level (post monsoon)	Fluctuation
Tettikunta	2	1	17.2	13.9	3.3
Gurrampod	3	1	18.5	15.4	3.1
Tipparti	3	1	19.0	15.8	3.2
Kankanalapalli	3	1	17.5	14.3	3.2
Nerada	2	1	18.2	15.1	3.1

4.4. Comparison between the Groundwater Configuration and Fluctuation

As mentioned in the earlier paragraph the area of investigation has been characterised by wells with distinct groundwater characteristics. The water table condition in the study area revealed that, it has been characterised by its configuration and fluctuation. The Fig.4.3 and Fig.4.8 respectively give the water table configuration and fluctuation data in pictorial form.

It is interesting to note that there has been a good relationship between the groundwater configuration and groundwater fluctuation of the area. It can be established that majority of the very shallow and shallow wells have fluctuations within the range of 0 m-2 m. Similarly, the moderately deep and deep wells can be specially correlated with wells having fluctuation from 2 m to more than 3 m (3rd and 4th categories). In other words the shallow wells have low fluctuation and deep wells have high fluctuation.

5. Conclusions

- The study area is characterised by the occurrence of wells under different depth categories (0-12 m, 12-15 m, 15-18 m and >18 m). It is observed that the majority of the wells occur in 12-15 m depth category and less number of wells occur in 0-12 m depth category
- The deeper wells mainly occur or observed to occur in the central and southeastern parts of the study area whereas the shallow wells are confined to northern, eastern and southeastern parts of the study area.
- As far as the water table fluctuation is concerned the Central part of the study area is characterised by low fluctuation where-

as the North western, South western and Eastern parts are characterised by high water table fluctuation. The important observation is that the deeper wells are having low fluctuation whereas the shallow wells are characterised by high fluctuation and high density lineaments.

- As far as the lineament pattern is concerned the highest lineament density occur in the northwestern part followed by moderate lineament density in southeastern and northeastern parts. The southwestern part show relatively less number of lineaments.
- Groundwater occurs in the study area under water table and semi-confined conditions limited to weathered and fractured zones. The zone of weathering ranges from 0 m (near inselbergs) to 17 m. The joints and fractures, which act as conduits for the movement of groundwater are responsible for the good yield of water from the wells.

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