

Influence of Geomorphic Characteristics and Geology on Ground Water Occurrence In Hard Rock Area, Part of Manair River Basin In Karimnagar District, Telangana State.

B. Satheesh, S. Sateesh Kumar

Department of Geology, Kakatiya University, Warangal-506009

*Corresponding Author: * B. Satheesh*

Abstract: *The Manair River is an important tributary of river Godavari and forms part of Karimnagar district of Telangana State. The geomorphological studies have been carried out with a view to understand the impact of these parameters over the ground water occurrence in the area. The area is covered with hard rock's i.e., granites and granitic gneisses traversed by dykes and numerous veins of quartz, epidote and pegmatite. The morphometric analysis has been carried out in addition to the study of land forms. The structural features has strong bearing over the development of drainage pattern and it is mostly dendritic to sub-dendritic nature and the Manair river is designated as sixth order stream. The lower value of bifurcation ratio is mainly due to gentle slopes owing to hard rock terrain. The geomorphic features such as pediplains, shallow valley fills and palaeo channels are considered to be potential aquifer zones. It has been also observed that the increasing order of drainage has increased the ground water potential.*

Keywords: *Drainage Characteristics, Morphometric Analysis, Geomorphic units, Land forms, Manair Basin, Karimnagar District.*

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I. INTRODUCTION

The morphometric analysis of a drainage basin and channel network play a significant role in understanding the hydrogeological behavior of the basin and express the prevailing climate, geology, geomorphology and structures etc. the relationship between various drainage parameters and the above factors are now almost well established (Horton, 1945; Strahler, 1957; Melton, 1958). Recently, several researchers have used remote sensing data and GIS on morphometric parameters and have concluded that remote sensing has emerged as a powerful tool in analyzing the drainage morphometry (Agarwal, 1998; Nag, 1998; Das & Mukarji, 2005) the present study mainly aims to analyse the morphometric attributes part of the Manair river basin around Karimnagar district.

II. STUDY AREA

Karimnagar District is part of the Telangana state, covering an area of 11,835 Km². Mighty Godavari is the northern boundary of the District separates from Adilabad District and Maharashtra State. Another major River Manair is flowing in the middle of the District in W-E direction and it is a tributary of Godavari and merging at Damarakunta Village of Kataram Mandal. The study area forms part of the Lower Manair basin covering an area of 671 km². This basin is located on the North Eastern part of the Karimnagar district lying between 17° 56' 18" - 18° 25' 38" and longitude 78° 45' 30" - 79° 17' 10" of East latitude in Survey of India toposheet No. 56 N / 3, 56 N / 4, 56 N / 6 & 56N/8 (Fig. 1) 1:50,000 Scale with an area of 671 Km² (Fig. 2). Investigation is intended to study the morphometric characteristic of the drainage basin with a special emphasis on ground water conditions on the area (Strahler's 1957).

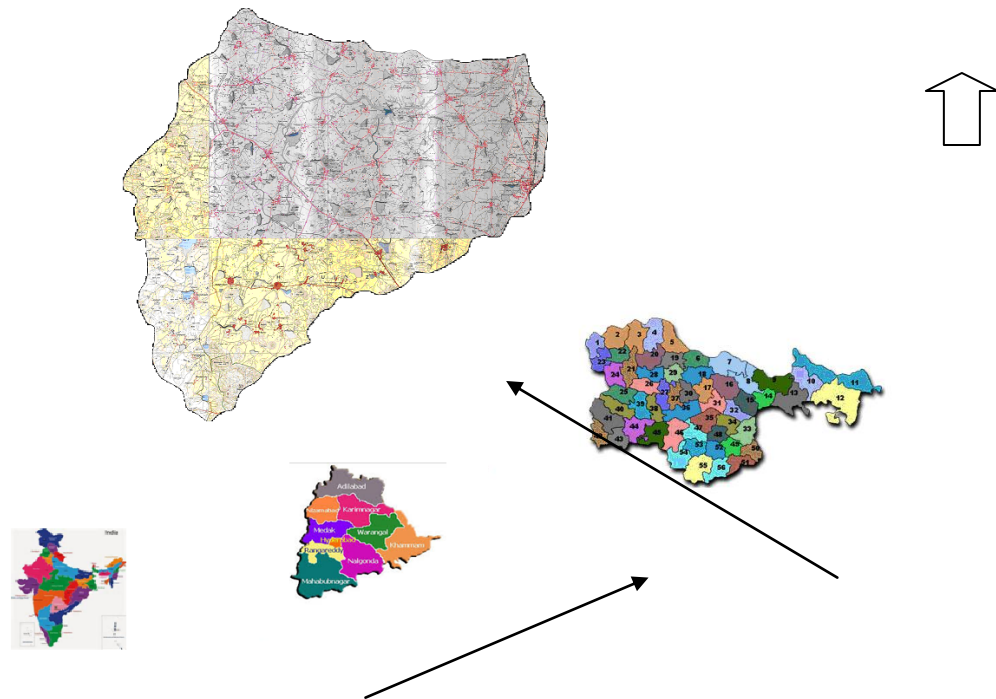


Fig.1 .Map showing the Study Area.

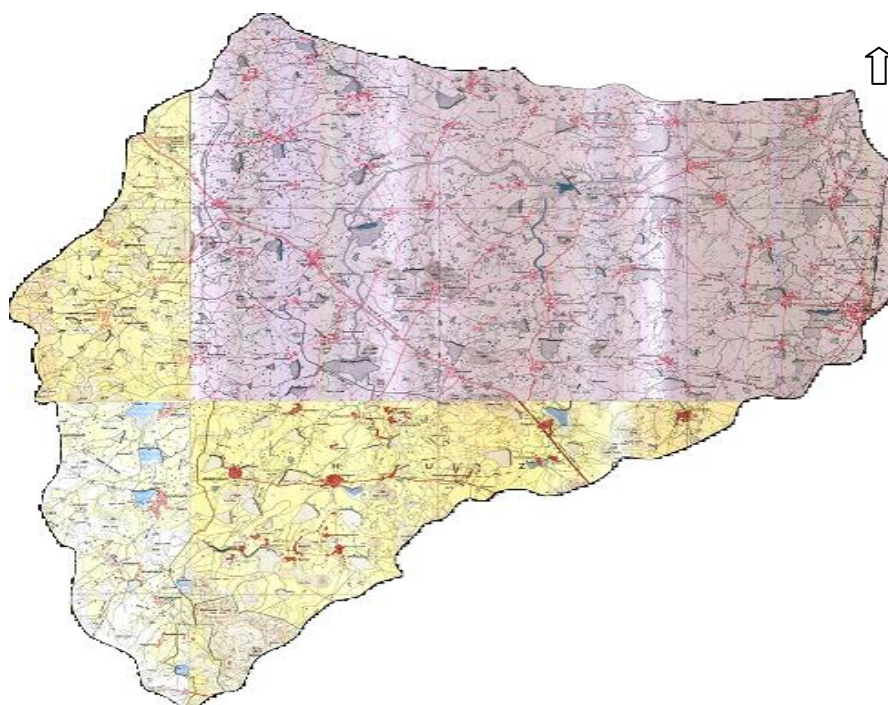


Fig. 2. Map Showing Toposheet of the Study Area.

Topography and Climate: The highest and lowest elevation from above Mean Sea Level (MSL) in the study area is 634 meters towards western side and 200 meters on southern side of the basin. The highest elevated area is observed at Saidapur with an elevation of 634 m above MSL which is located on the South-Western part of the basin. On the Northern side of the basin the Veenavankagutta with an elevation of 400 m, the eastern part of the basin near Jammikunta with an elevation of 450m, and on the Western side of the basin nearby Manakondur with an elevation of 400 m. Climate is the more important natural phenomenon which controls the growth at living organism's development of soil, surface and sub surface water resources, etc. The climate of the area is generally hot and dry with the temperature varying between 13 to 46° C and occasionally touches 49°C and it is considered to be semi-arid tropics.

Rainfall is the major source of groundwater recharge in the study area. The distribution, duration, intensity and frequency of occurrence of rainfall are some of the primary factors that govern the distribution of water in the land surface and sub-surface. Protected open forest, which covers 8% percent of the total area of the study area, is covered with limited flora and fauna. Many plant species have disappeared due to deforestation. However Teak, Bamboo, Buruf, etc., are some of the dominating varieties of plant species which are present in the forest area. This flora plays vital role in recharging the water in the study area. The remarkable hills with an average elevation of 632 m are observed on the West to Northern parts of the area and also at southern part with an elevation of 620 mts. There are two types of soils are found in the area, they are Red soils and Black cotton soils.

Geology of the Area: The area forms part of the Peninsular shield represented by the Granites, Granitic gneisses and schist's which are traversed by dolerite dykes and numerous veins of quartz, pegmatite and epidote. The granites and granitic gneisses are massive and fractured created the secondary porosity. At places, granodiorites and charnokites occur as small patches within the granitic terrain (Fig.3).

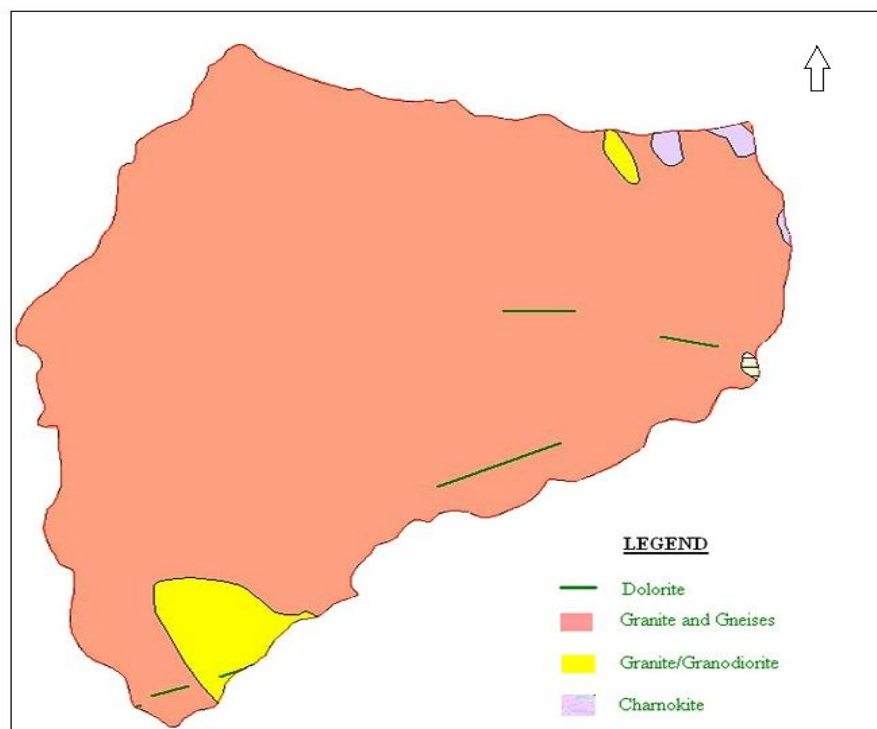


Fig.3. Geology of the Study Area

Basin Morphometry: The drainage system constitutes the main stream and its tributary network. The study of drainage basin gives a detailed account of runoff, infiltration, sediments lodes carried by streams etc., which are suitable for tapping groundwater. The size of the drainage basin influences the yield of the basin. The analysis includes stream order, streams length, stream length ratio, and length of overland flow, elongation ratio, circularity ratio, bifurcation ratio, drainage density, drainage frequency and drainage texture. The drainage network of the basin has been analysed following the procedures of Horton (1945) and Strahler (1964, 1968).

Stream Order: The effectiveness of a drainage development is related to stream magnitude so that the stream order is considered as an important parameter in a linear aspect of drainage basin. The designation of various stream orders was first introduced by Horton (1945), and was later modified by Strahler (1952, 1958). The first order streams have no tributaries (Strahler 1964). The second order streams have the tributaries of only first order channels. A segment of third order is formed, where two-second channels join when two third order segments join, a fourth order channels is formed. When third, fourth order segments join a fifth order channels is formed, when fourth, fifth order segments join a sixth order channel is formed. Accordingly the Manair basin is designated as six order basin. The stream order is generally designated by the letter 'U' and the total numbers of streams are indicated by 'Nu' (Table - 1). There are as many as 1159 first order streams, 298 second order streams, 77 third order streams, 18 fourth order streams and 5 fifth order streams, with a single sixth order stream. Hence it is designated as part of sixth order basin.

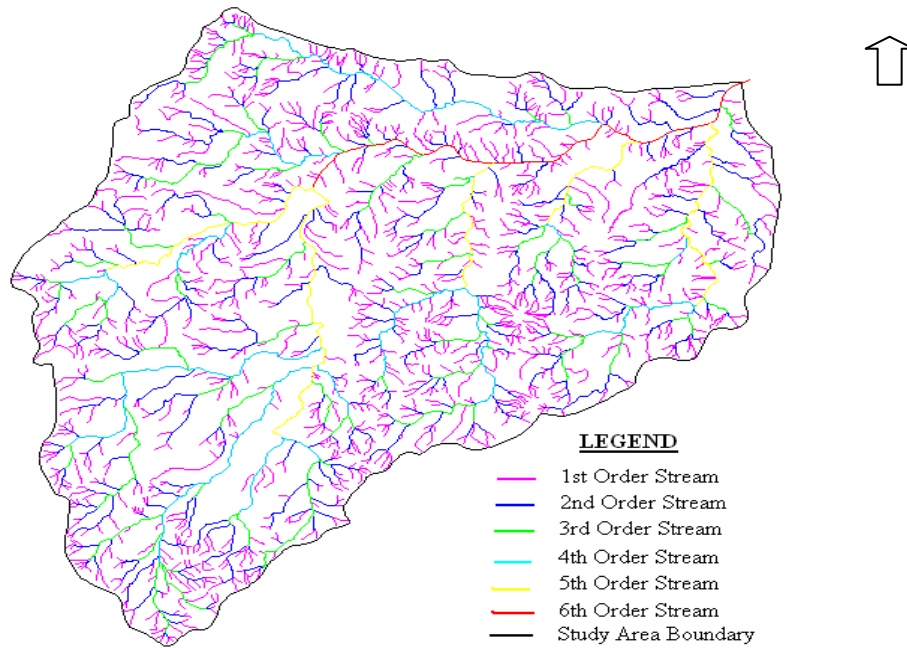


Fig. 4. Map Showing Study the Drainage Pattern of the area

Table –1: Drainage parameters of Manair basin

S.No.	Stream order	No. of streams of given (Nu)	Stream length (Lu)
1	1	1159	841.19
2	2	298	401.00
3	3	77	260.00
4	4	18	95.40
5	5	05	55.08
6	6	01	22.40

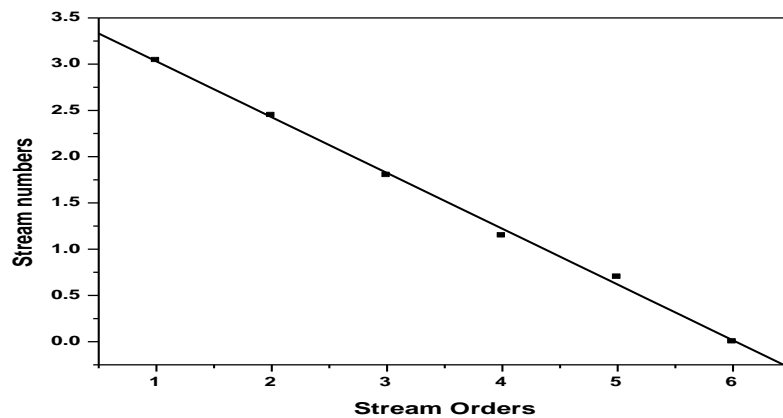


Fig. 5. Geometric relationship between stream orders and number of streams

Stream Length: Stream length is a dimensional property to understand the characteristic size of components of a drainage network. Total length of stream segments maximum is 846.19 km. In the case of first order streams (Table 1) and almost in all cases, the basin length decreases, as the stream order increases the length decrease.

Stream Length Ratio: Stream length ratio has an important relationship with surface flow discharge and erosional stage of the basin. Streams flow smaller in number and greater in length in more permeable areas. The length of the various stream segments were measured order wise and the total length as well as the mean length for each order were computed. The stream length ratio which is the ratio of the mean length of the steams of a given order to the mean length of the streams of the next lower order has been calculated for each pair of orders as shown below. The mean length of the streams increases with the order in direct proportion and brings out this exponential relation clearly. The best-fit regression equations were obtained as in the semi-logarithm plot of mean

length against order is more or less straight lines satisfying (Fig.6). Horton’s second law of stream lengths which states that the average length of streams of each of the different order in a drainage basin tends closely to approximate a direct geometric series in which the first term is the average length of the streams of the first order.

$$RL = Lu / Lu-1$$

Where RL is the stream length ratio, Lu is the mean stream length order (u) and Lu-1 is the mean stream length of segments of the next lower order. The stream length ratios of the Manair basin range from 1.547 to 2.72 (Table-2). The mean length ratio obtained from the regression co-efficient is 1.23 and mean length ratio is 2.180. The variation in the stream length ratios may be caused by the difference in slope and topographical conditions.

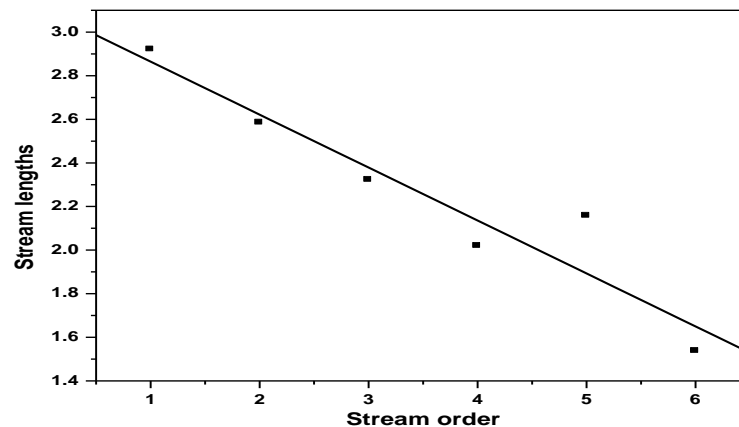


Fig. 6. Geometric relationship between stream orders and stream length (Km)

Table -2: Stream length ratio

S.No.	Length of each stream order	Stream length ratio	Mean stream length ratio
1	841.19	2.109	2.180
2	401.00	1.541	
3	260.00	2.72	
4	95.40	1.732	
5	55.08	2.458	
6	22.4		

Circularity Ratio: Circularity ratio is a quantitative expression of the shape of a basin. It is defined as the ratio of basin area to the area of a circle having the same perimeters as the basin (Strahler, 1964: Miller, 1953) and is expressed as

$$RC = 4\pi A / P^2$$

Where RC = is the circularity ratio, A is the area of a basin and P is the basin perimeter.

The circularity ratio is generally influenced by length, frequency and gradient of streams of various orders rather than slope and drainage conditions of basin. Low, medium and high circularity ratio values are indicative of youth, mature and old stages respectively of the basins. For this basin the circularity ratio is found to be 0.1

Bifurcation Ratio: Bifurcation Ratio is used to express the ratio of a number of streams of any given order to a number in the next lower stream order (Horton, 1932). The ratio of a number of streams of a given order to the number of segments of the higher stream order is termed as the bifurcation ratio, as shown in the following formula

$$Rb = Nu / Nu + 1$$

Where Rb is the bifurcation ratio, Nu is the number of stream segments and Nu+1 is the number of stream segments of the high orders. The bifurcation ratio varies from 2.57 to 5 (Table. 3) with mean of 4.1352 as a whole for the Manair basin. The higher bifurcation ratio for V and III order streams in the basin respectively, may be attributed to the development of streams in steeply dipping rock strata. The values of bifurcation ratio less than 5 suggest that the geological structures do not show any dominant influence on a drainage pattern. Such values denote a mature development of the basin.

Table.3. Bifurcation ratio

S.No.	No. of streams of each order	Bifurcation ratio	Mean Bifurcation ratio
1	1155		
2	298	3.89	
3	77	3.87	
4	18	4.27	3.92
5	05	2.57	
6	01	5	

Elongation Ratio: Schumm’s (1956) elongation ratio is the ratio between the diameter of a circle of the same area of a drainage basin and the maximum length of the basin. Higher the elongation ratio lesser will be the flood peak. For this basin the elongation ratio is 0.74. The shape of a drainage basin is significant since it affects the stream drainage characteristics (Strahler, 1958). The low form factor, circularity ratio and higher elongation ratio suggests the basin is more elongated.

Stream Frequency: Stream frequency (Horton, 1945) refers to the number of the streams per unit area and is obtained by dividing the total number of streams by the total drainage basin area. This basin has a stream frequency of 2.371. Stream frequency helps in distinguishing the groundwater recharge characteristics in a river basin.

$$F_s = L_u / A_u = 1558 / 671 = 2.371$$

Where F_s L_u is total number of streams, A_u is Total area of the drainage basin

Drainage Density: Drainage density is a measure of degree of drainage development within a basin. It reflects closeness of spacing of channels, attributing due to differential weathering of various formations, relief and rainfall in an area. According to Horton (1932), the drainage density is defined as the length of streams per unit of a drainage area divided by the area of the drainage basin. It is expressed as

$$D_d = L_u / A = 1680 / 671 = 2.504 \text{ km/km}^2$$

Where D_d is the drainage density, L_u is the length of all the other streams and A is the area of the basin, Smith (1950) and Strahler (1957) have described drainage density values less than 5 as coarse, between 5 to 13.7 as medium, between 13.7 to 155.3 as fine, and greater than 155.3 as ultra fine. Chow (1964) is of the opinion that the low drainage density is favored in regions of highly resistant or highly permeable sub-soil materials under dense vegetation and low relief, while the high drainage density is favored in regions of weak or impermeable sub-soil materials, sparse vegetation and mountain relief.

The drainage density computed according to Horton’s formula in the manair basin is 2.504 km/km². It suggests that the drainage density is low, reflecting a permeable sub-surface stratum with dense vegetation and low relief, which is a characteristic feature of coarse drainage density.

Drainage Texture: Drainage texture is a measure of closeness of the channel spacing. It depends on climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development of drainage (Smith, 1950). Weak rocks produce fine texture, while hard rock’s develop coarse texture. Sparse vegetation of an arid climate causes develop on similar rocks in a humid climate. The texture of a rock depends upon vegetation and climate causes development of fine texture than those developed on similar rocks in a humid climate. The texture of a rock depends upon vegetation and climate conditions (Dornkamp and King, 1971). The drainage texture is computed, using the formula

$$T = D_d \times F_s = 2.504 \times 2.321 = 5.81 \text{ D}^2$$

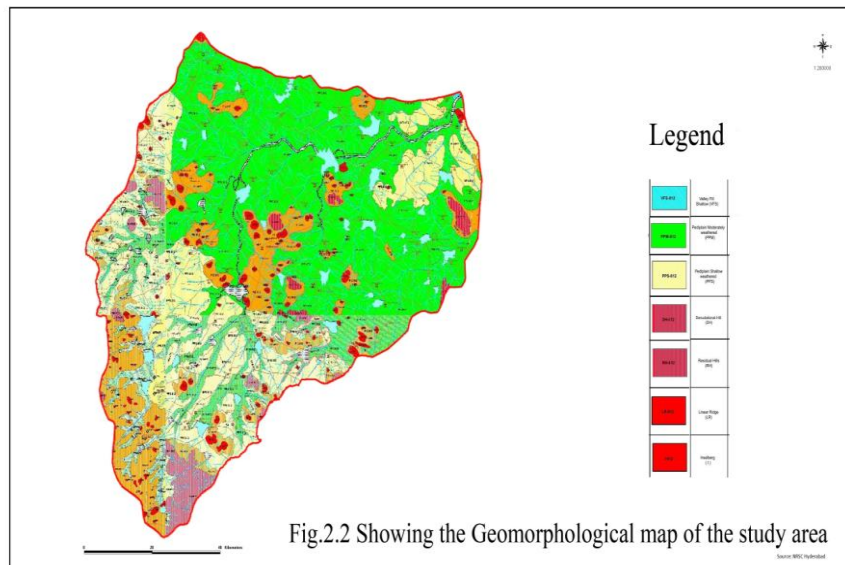
Where T is the drainage texture, D_d is the drainage density and F_s is the stream frequency

The drainage texture of the Manair basin is 5.81 D^2 . According to the classification of drainage texture (Smith, 1950), gentle slopes and almost flat topography may cause the fine texture with lesser rainfall intensity. The intermediate texture may be attributed due to sub-humid climate with hard rock formations.

Geomorphology: It is one of the most significant features in evaluation of the groundwater potential. Considering the importance, different geomorphic surfaces are mapped using the satellite imagery. Based on geology, Geomorphology and ground checks, the following 8 hydro-geomorphic units were delineated using the satellite imagery (Fig.4). The geomorphic surfaces obtained are:

- DENUATION HILLS (DH)
- PEDIPLAIN (PP)
- PEDIPLAIN SHALLOW WEATHERED (PPS)
- PEDIPLAIN MODERATELY WEATHERED (PPM)
- RESIDUAL HILLS (RH)
- SHALLOW VALLEY FILLS (VFS)
- CHANNEL ISLAND (CI)

DYKE RIDGES (DR)



Well Inventory data were also collected during the field visit to know the weathering thickness and groundwater potentials of various geomorphic units in the study area.

1. DENUDATION HILLS (DH): There are relict hills which are found due to differential weathering. The lithological constituents of these hydrogeomorphic units are granites and gneisses occurring as extensive massive elevated hill ranges. They are found to occur in the middle and upstream area bordering the basin boundaries. Recharge is poor and forms as runoff zones and less suitable for groundwater prospects. These are observed north side of the study area Veenavanka, Jammikunta, Chinthagattu, Chenjarla and Kothapeta villages.

2. PEDIPLAIN (PP): The term Pediplain is generally used to describe a series of coalescence of pediments (Thornbury, 1954). Depending upon insitu conditions such as rock type, topography, structural features and geomorphic features acted upon them, the developments of individual landform units differ considerably as observed at Saidapur area.

3. PEDIPLAIN SHALLOW WEATHERED (PPS): This is a gently sloping surface of weathered pediplain with 0-10 m thick weathered material and usually covered with red soils. These landforms spread the study area covering in Gaddipaka, Ganmukula, Narsingapur, Pothireddypally, Keesapuram areas of the area. Aquifer material is fractured weathered and fissured rock and the recharge is moderate. The ground water prospects are moderate to good. During the field investigations it is noticed that many dug wells and dug cum bore wells were dried up especially during summer.

4. PEDIPLAIN MODERATELY WEATHERED (PPM): It is almost flat to gently undulating plain formed by the coalescence of several pediments and varying in thickness of weathered material from 10 to 20 mts. Aquifer material is in weathered and fractured rock. Weathering is not uniform. Recharge is good and groundwater prospects also good.

5. RESIDUAL HILLS (RH): Residual hills are the end products of the process of pediplanation, which reduces the original mountain masses into series of scattered knolls on the pediplains (Thornbury, 1990). They occur as isolated hills of small areal extent and found at lower altitudes as compared to denudation hills. These are observed mainly at west of Ghanapuram, Akunoor, Ramchandrapuram, Shivarampally, Saidapur village. Limited recharge conditions and ground water prospects are poor in these zones.

6. SHALLOW VALLEY FILLS (VFS): This unit occurs as narrow linear shape all along the drains in the study area and filled with partially loose sediments with thickness ranging from 0-10 mts. Thus reflected the recharge conditions are very good.

7. CHANNEL ISLAND (CI): This unit occurs in the extreme downstream side of the study area with small areal extent formed in the river course. This zone acts as a very good recharge zone.

8. DYKE RIDGES (DR): An elongated linear ridge are found in the area which are found to be the weathered remnants of dykes. They are equally slopping on either side and having run-off conditions wherein poor recharge.

Based on the geomorphology and morphometric analysis, it is a sixth order stream. The drainage and morphology of the area is controlled by the lithology and secondary structures such as joints and fractures. Pediplains, shallow valley fills and Channel Islands are considered to be potential aquifer zones in addition to the junctions of intersection of higher order streams.

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