INTRODUCTION

The main interest of hydrologists is the distribution of precipitation in time and space and its subsequent disposal after reaching the land surface.
CHAPTER – I

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In solar system the earth is the only planet bestowed with water and most of it is saline. The focus of human civilization today is for fresh water resources. The total quantity of water on the planet earth remains same though its form changes in time and space. The complexity of climate directly influences the availability of water resources in one form or other. The main source of water in India is monsoon rains. The rainwater received during monsoon season and it is stored naturally or artificially over and under the ground surface to be used in non-monsoon reason. The arid and semi arid areas face the water scarcity regularly. Even the area receiving highest rainfall also faces the scarcity during lean period.

Groundwater forms an important part of the earth's water circulatory system known as the hydrologic cycle. Haphazard and indiscriminate use of water resources has resulted in depletion of groundwater reservoirs. The sustainability of this ubiquitous resource has become a doubtful proposition. Access to safe drinking water is still a distant reality for most population in rural and urban areas.

The occurrence of groundwater in hard rock terrain mainly depends on geological structures and geomorphologic characters. The meteorological parameters over the terrain are also important factors that control the occurrence of surface as well as groundwater paucity, good water resources and uneven distribution of rains has caused a serious concern to all and more so to the geologists.

Keeping these points in mind the present study is devoted to a watershed in semi arid regions of Karnataka. The Asundi Nalla Watershed is the study area, selected for the present study. Hereafter, the Asundi Nalla Watershed will be said as ANW.
LOCATION

Geographically the ANW found in Haveri District of Karnataka State, India. The area is located between latitude 14° 35' and 14° 49' N and between longitude 75° 29' and 75° 42' E and found in toposheet no. 48 N/6,9,10. Geologically the area is in Precambrian terrains of Karnataka. The greywackes are the litho units. The watershed covers an area of 230 sq.kms. The area is close to National Highway no. 4 and nearby Haveri and Ranebennur Cities (Fig. 1.1).

SIGNIFICANCE OF THE WATERSHED

The ANW is a small drainage basin joining Tungabhadra River. It drains over greywackes, which are less altered but highly fractured and jointed. The watershed faces the scarcity of surface as well as groundwater. The watershed experiences semi arid climatic conditions with little natural vegetation.

ACCESSIBILITY AND VEGETAION

All the villages are accessible by good motorable all season roads (Fig. 1.2). Most of the roads are metalled and tar roads permitting easy access to any part in dry and wet seasons. One to two kilometers walk is unavoidable to reach bore wells in the agricultural lands and even to study some of the outcrops.

The natural vegetation is in the form of thorny bushes and shrubs. (Photo.1). Wherever water sources are available cultivation is fairly good (Photo 2&3). The ANW comprises of 41 villages.

PERVIOUS WORK AND PRESENT WORK

Department of Mines and Geology, Government of Karnataka has fixed four observation wells in ANW and water levels are recorded since 1976. The data is not regularly recorded and is missing for some years for unknown reasons. The ANW is considered for the development before 1970 by Government of Karnataka, Dept. of Minor Irrigation. The meteorological data of four meteorological stations is available in the District Statistical Office,
Dharwad. The occurrence and petrological aspects of greywackes in Haveri District are studied by M. Phil. and Ph.D. students of Department of Studies in Geology, Karnataka University, Dharwad.

In the present thesis the hydrogeological features of the ANW are accomplished by studying following:

1. Physiography / Geomorphic features.
2. Morphometric analysis.
3. Hydro meteorological factors.
4. Geology and soil characters.
5. Groundwater characters
8. Groundwater management.
10. Use of satellite imagery for land use and land pattern and other studies.
11. GIS softwares are used for interpretation of primary and secondary data.

HYDROMETEOROLOGY

Meteorology is the science that deals with the atmospheric process of the hydrologic cycle and hydrometeorology may be defined as the study of atmospheric processes, which affect the water resources of the earth. Such features are of interest to the hydro geologists. The hydro geologic characters of any area primarily depend on its climate, topography and geology. Topography is an important factor that affects the precipitation and runoff. Geology influences topography and underlying rocks in groundwater zones. The climate mainly depends on the geographical position on the earth’s surface in terms of latitude, altitude, and coastal or inland location. The important climatic element is precipitation i.e. rainfall and its mode of occurrence and distribution. This largely controls the groundwater recharge and surface runoff. The other elements of hydrological cycle are temperature, humidity, wind velocity, evaporation, evapotranspiration, etc.
In the present study the meteorological parameters like relative humidity, temperature, sunshine; evaporation wind velocity, etc. are studied. The above said metrological data are collected for 7 years (1998 – 2004) from Dept. of Mines and Geology, Government of Karnataka, Dharwad. The rainfall data of 15 years (1990–2004) are collected from same office for Ranebennur, Asundi, Ukkunda, Hanumanamatti and Maidur station.

The meteorological and the rain gauge station are established in the year 1998 and 1990 respectively.

Analysis of Rainfall Data

The analysis of rainfall data is of great importance in hydrogeological studies. The rainfall is the input of water into the surface of the earth to form streams and rivers and infiltration to recharge aquifer zones. The rainfall data is analysed on following lines.

1. Annual rainfall
2. Arithmetic mean and volume of rainfall
3. Seasonal variation
4. Distribution
5. Isohyetal map
6. Departures and drought

Annual Rainfall

The table 1.1 below gives the average month wise distribution of rainfall in mm for 15 years (1990-2004) at four rain gauge stations within the ANW. The table 1.1 reveals that in the month of October the rainfall is more at all rain gauge stations, followed by the month July, August and September and June. In the months of December, January, February and March the ANW receives minimum rainfall. The arithmetic mean of the rainfall is calculated for 15 years and it is 516.28 mm. The total volume of rainfall received can be obtained by
average rainfall over the area of the basin (ANW) in sq.kilometres. The total volume of rainfall over ANW years is calculated thus;

\[ \text{The area of ANW} \times \text{Average rainfall over ANW} \]

\[ = 230 \text{ sq.kms} \times 516.28 \]

\[ = 118744.4 \text{ mm km}^2 \]

\[ = 230 \times 1000 \times 1000 (516.28/1000) \]

\[ = 1187444 \times 10^3 \text{ m}^3 \]

Anantha Krishnan and Rajagopalachari (1963) have classified the calendar year into 4 seasons for Indian condition and they are,

<table>
<thead>
<tr>
<th>June – September</th>
<th>SW Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>October-November</td>
<td>NE Monsoon</td>
</tr>
<tr>
<td>December-February</td>
<td>Winter</td>
</tr>
<tr>
<td>March-May</td>
<td>Summer</td>
</tr>
</tbody>
</table>

Based on the set seasons the percentage of annual rainfall for southwest monsoon and northeast monsoon are calculated and tabulated in table 1.2. This table reveals that ANW receives 52.53% of rains during SW monsoon and 30.89% of rains during NE monsoon.

Sarma et al (1982) have calculated the co-efficient of variation (CV) in order to study the distribution of rainfall they have suggested five classes based on CV as shown below.

<table>
<thead>
<tr>
<th>DISTRIBUTION</th>
<th>CV VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>0-25</td>
</tr>
<tr>
<td>Normal</td>
<td>25-50</td>
</tr>
<tr>
<td>Medium scattered</td>
<td>50-75</td>
</tr>
<tr>
<td>Heavy largely scattered</td>
<td>75-100</td>
</tr>
<tr>
<td>Very heavy scattered</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

The CV values are calculated for each rain gauges station and given in table 1.3. The CV values are above 50. On many occasions it is more than 100.
This indicates that the rainfall is medium to very heavy scattered at all rain gauge stations.

The rainfall data from all stations is used to depict isohyetal map to study the overall distribution of rainfall over ANW. The isohyetal map drawn for ANW is shown in Fig. 1.3. This Fig. 1.3 reveals that maximum rainfall occurs in the southern part of the ANW i.e. 570mm, minimum rainfall occurs in the central part of the ANW i.e. 440-480mm. The northern part of ANW receives about 480-500 mm rainfall.

To know the variation of rainfall in 15 years, a variation diagram is plotted and given in Fig. 1.4. The Fig. 1.4 also shows the average line. Only six points are above average line. This indicates that ANW is normally receives rainfall below average.

The departure values of each year are calculated and given in table 1.4. Based on the departure values for types of droughts are defined by Bangar (2000) and they are;

<table>
<thead>
<tr>
<th>Departure Values</th>
<th>Type of Drought</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>Mild drought</td>
</tr>
<tr>
<td>25-50</td>
<td>Normal drought</td>
</tr>
<tr>
<td>50-75</td>
<td>Severe drought</td>
</tr>
<tr>
<td>75-100</td>
<td>Most Severe drought</td>
</tr>
</tbody>
</table>

The departure values obtained for ANW are less than 25 indicating that ANW has experienced mild drought for last 15 years.

**Other Meteorological Parameters**

The meteorological parameters like relative humidity, wind velocity, temperature (min and max), sunshine, and evaporation are collected for seven years (1998-2004) from Ranebennur station. The details of all parameters are given in table 1.5 along with average values of all parameters.
The relative humidity expresses the degree to which the air is saturated with moisture. The relative humidity values for ANW are high (79-80) in the month of June, August, September and October. Its values are low in the months of December and January (59 – 60).

The wind velocity is a vector quantity and equals speed in a particular direction. In common usage the wind velocity refers to speed of motion with reference to direction. The wind velocity values for ANW are high (7-8 kms./hr.) in the months of June and July and are very low in the months of November, December, January and February (1 to 2 km/hr).

The temperature values are normally recorded as maximum and minimum. The temperature values for ANW are high (36 to 37°C) in the months of April and May and low (17 to 18°C) in the months of December and January.

The sunshine values for ANW are high 7 to 8hrs/day in the months of November to May and low (3 to 5 hrs/day) in the months of June to September.

The evaporation is a process by which precipitated water on the earth’s surface is returned to the atmosphere by vaporization and is measured in min/day. The rate of evaporation depends upon several factors such as temperature of the air and water relative humidity, wind velocity; water quality, solar radiation etc. evaporation changes the chemistry of groundwater. The evaporation values are high (7 to 8mm) in the months of March, April and May and low (3 to 5mm) in the other months, for ANW.

The values of evapotranspiration are calculated by Thornthwaite (1948), and Penman methods (1948). The results are given in table 1.6. The monthly mean temperature is calculated by Eagleman’s method (1967). The values are given in table 1.6. The monthly water loss is calculated by Khosla’s method (1967). The values are given in table 1.6. The above parameters namely
evapotranspiration, monthly mean temperature and monthly water loss are calculated months wise for average of seven years data.

The runoff of any drainage of basin depends on the topography, intensity of rainfall, dimensions of basin, soil, geology, vegetation and other ecological conditions. The runoff factors are calculated utilizing the empirical formula given by Inglis (Raghunath, 1987),

\[ R = (P - 17.8) \frac{P}{254} \]

Where \( R \) = runoff in cm

\( P \) = rainfall in cm

The runoff values calculated for each rain gauge stations are given below,

<table>
<thead>
<tr>
<th>Rain gauge station</th>
<th>Average annual rainfall in cm</th>
<th>Computed runoff in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranebennur</td>
<td>57.4</td>
<td>8.94</td>
</tr>
<tr>
<td>Asundi</td>
<td>42.87</td>
<td>4.23</td>
</tr>
<tr>
<td>Ukkunda</td>
<td>57.14</td>
<td>8.84</td>
</tr>
<tr>
<td>Hanumanamatti</td>
<td>53.12</td>
<td>7.38</td>
</tr>
<tr>
<td>Maidur</td>
<td>47.58</td>
<td>5.57</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>51.62</strong></td>
<td><strong>6.99</strong></td>
</tr>
</tbody>
</table>

**GEOLOGY AND SOILS**

Greywackes cover 95% of ANW. Only 5% of the ASW is covered by banded iron formations, shale and argillite in the southeastern corner of the basin and found in the hills of this area (Fig. 1.5). The greywackes is the term applied to indurated sandstones composed of more than 50% chlorite – sericite matrix with more than 5% of feldspar. Pettijohn (1984) opined that the upper size limit of matrix is 30 microns.

The greywackes of the ANW are outcropping in the slopes of hills and plain region covered with thick soil (Photos 4, 5, 6, 7 and 8). They are grey in colour, angular to subangular, immature sediments. These exhibit typical
Dharwarian strike direction and also dip direction. The greywackes strike N 10° W to S 40° E and the amount varies from 60° to 80° due east. These exhibit bedding, strike as well as oblique joints and concoidal fractures. The stratification features are common. The convolute type of folding is observed at places.

These greywackes occur as massive formations with thin bands of argillites/phylites and pelitic beds. The freshly cut hand specimen exhibit light grey to dark grey colour. They are hard, tough and strongly indurated. The megascopic study reveals that there is variation in grain size from place to place. The hand specimen also exhibits the presence of quartz and specks of pyrite through naked eyes. At places a rude schistocity is observed. The rude schistocity indicate the effect of metamorphism on these rocks.

These greywackes are metamorphosed to low-grade greenschist facies. The metamorphism has not changed the original detrial grain shape. Some of voids in greywackes are filled in by secondary carbonates (calcite).

The microscopic study of some of the thin sections reveal that the greywackes exhibit poorly sorted texture. The major constituents are quartz and feldspars, along with fragments of quartzite/chert and phyllite. Quartz shows both monocrystalline and polycrystalline character. Quartz at places exhibits cloudy extinction and corroded margin. Feldspar is mostly plagioclase in character. Both fresh and altered plagioclase is present. The plagioclase is irregular in shape and looks dusty. Pyrite and ilmenite are opaque minerals.

The presence of quartz is more than 40% and feldspars is about 10% while the distribution of matrix is about 30%. The greywackes have suffered minimal chemical weathering.

SOIL means all naturally occurring unconsolidated material, which is uppermost part of regolith. This is produced by weathering of rocks. As said earlier large part of the ANW is covered by plain area with thin layer of soil cover (1 to 1.5 mts thick). The field traverses do reveal that the soil is grey to reddish grey in colour (Photos 9 and 10). In order to understand varies characters
of soil cover satellite imagery data is used. Based on satellite imagery studies four types of soils are identified. The four types of soils are shown in Fig. 1.6

The brief characters of these soils are:

Type I

This type of soil is found in the southern and central part of ANW and is represented by brown colour in Fig. 1.6. The soil here is thick and moderately well drained. Here along slopes the soil is subjected for severe erosion. The soil is clayey in character.

Type II

This type of soil is found in the eastern, northwestern and southern part of ANW and is represented by light green colour in Fig. 1.5. This soil is moderately shallow and well drained. It is gravelly clayey soil on gentle slopes. This soil is moderately eroded.

Type III

This type of soil is found in southwestern corner of ANW and is represented by light violet colour in Fig. 1.5. This soil is shallow, well drained and gravelly clayey in character.

Type IV

This type of soil is found in the central and northern part of ANW and represented by light pink colour in Fig. 1.6. The soil is thick and occurs in gently sloping and valley portions. They are moderately well drained and calcareous and cracking clayey in character.