ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

Hydro geological and Geomorphometric Characteristics of Dhamuda Nala Watershed, Parbhani District, Maharshtra, India

Bochare Krishna S., Bamne Arjun M., Bawri Hardeepkaur S.C., Jadhav Snehal, Muley R.B. and Md. Babar*
Department of Geology, D.S.M. College, Parbhani, Maharashtra, India

Abstract—* The geomorphometric analysis of Dhamuda nala watershed in Parbhani district is carried out in order to hydrogeological implication. For this purpose some basic parameters are measured including basin perimeter, basin length, elevation and other aerial parameters were calculated by using Arc Map (10.1) software. Total area of the watershed is 133.64 km^2. Geologically investigated area is covered by Deccan volcanic basalts which are upper Cretaceous to lower Eocene age. Quantitative analysis of drainage network shows that the dendritic to sub dendritic drainage pattern is developed in the sub-basin. Bifurcation ratio of watershed ranged from 2.0 to 4.28 and it is not affected by any structural control. Drainage texture in the investigated area indicates massive and resistant rocks cause coarse texture. Drainage morphometry is useful to signifying the construction sites for artificial recharging structures for implication of hydrology. The groundwater in the study area is restricted mostly to the zones of secondary porosity developed in these rocks due to fractures, joints and weathering.

Index Terms— **Hydrogeology, geomorphometric analysis, Dhamuda watershed, Deccan basalts.**

I. INTRODUCTION

The population growth has been creating more and more stress on agriculture sector for increasing the food grain production, which consequently increased deforestation and demand for more water. The available surface water resources are inadequate to meet the entire water requirement for various purposes. So the demand for underground water has increased over the years. Generally, groundwater is less prone to pollution in comparison to surface water. Hence, groundwater serves as an important source of water for various purposes in rural and urban areas. In recent years intensive use of satellite remote sensing has made it easier to define the spatial distribution of different groundwater prospect classes on the basis of geomorphology and other associated features [1] - [8].

In many earlier studies [9] - [15] remote sensing techniques have been applied for groundwater prospecting. From the groundwater point of view integration of geological, structural and hydrogeological data with geomorphological data is very much useful in finding out the groundwater potential zones with fruitful results. In the present study, an attempt has been made to evaluate the groundwater potential of the Dhamuda watershed, Parbhani district, Maharashtra.

The study area, Dhamuda nala watershed (Fig. 1) in Parbhani district is bounded by latitude of 19^{0} $22^{|}$ N and 19^{0} $33^{|}$ N and longitude 76^{0} $68^{|}$ E and 76^{0} $91^{|}$ E and is included in the toposheet no. 56 A/11, 56 A/15 and 56 A/16 It is a tributary stream of Purna river and covers an area of 133.64 sq km in Parbhani tahsil.

II. METHODOLOGY

The present area is studied from the point of view of quantitative geomorphology using the toposheet maps No.56 A/11, 56 A/15 and 56 A/16 on the scale 1: 50,000 supplemented with IRS-P6 LISS-IV satellite imagery (FCC-geocoded) on the scale 1: 50,000. The detailed morphometric analysis is carried out in order to understand the drainage pattern, nature of topographic contour, basin shape, spot heights, slopes and altitude. Data on depth of water level was collected from dug wells in pre and post monsoon to find out water level fluctuation in the area.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

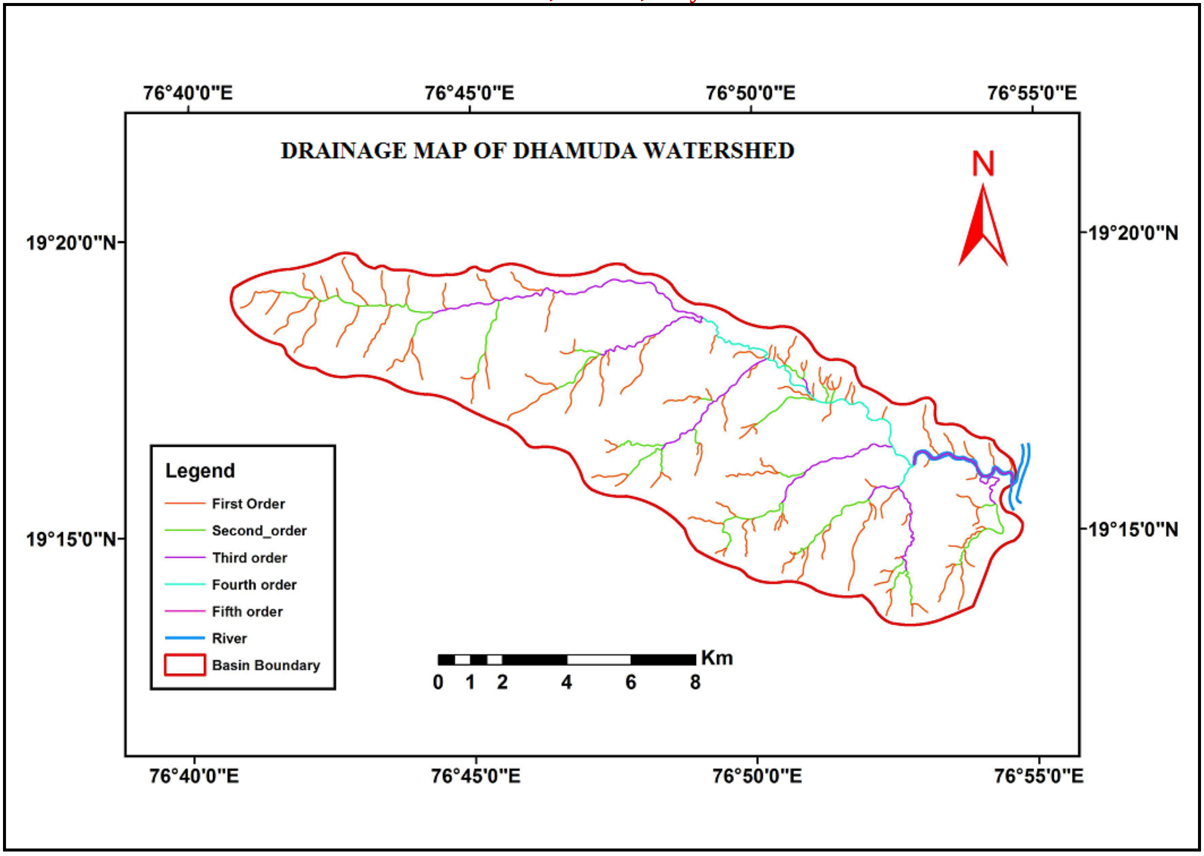

Fig. 1: Drainage map of Dhamuda watershed

The morphometric analysis of the Dhamuda nala watershed was carried out from the study of drainage network and contour pattern using the survey of India topographical maps on 1: 50,000 scale. The stream ordering was done by following the method of [16]. The smallest unbranched stream segment was designated as the first order stream, the one formed by the merging of two such first order stream segments was designated as the second order and so on stream segments of each order were counted and the lengths of various stream segments were measured order wise using the ARC GIS 10.1 Software. Total lengths for each order were computed (Table 1). The area of the drainage basin is measured in the GIS environment.

The relief (gradient) of the watershed was determined from the total drop in elevation from the source to the mouth of the river (Stream) and the horizontal distances between these along the river course. Longitudinal profile of the watershed is drawn from these data. The study of altitude distribution of ground surface of the watershed was carried out. For this purpose the height of the contour above the base level of mouth of stream is determined and the area enclosed between a contour within the watershed and the watershed boundary is measured using GIS.

The well inventory of 22 numbers of well is carried out with the help of standard format. The work of inventorying wells, which consisted of interviewing a well owner, taking a diameter, depth of well and depth of lining of the well along with water level measurement and completing the well inventory form.

III. GEOLOGY

Geologically, the entire study area (watershed) in Parbhani district is covered by Deccan Basalt formations (Fig. 2) comprising nearly horizontal lava flows. These flows have been considered to be a result of fissure type of lava eruption during late Cretaceous to early Eocene period. The types of basalt occurring in the area are compact basalt, vesicular-amygdaloidal basalt and red bole beds (Tachylitic bands) as observed in the well sections. The Deccan Basalt in this area has been assigned to Ajanta formations which are stratigraphic equivalents of Upper Ratangad formations of Western Maharashtra comprising compound flows [17].

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014
As the basalts are formed by cooling and solidification of the lava, they contain gas cavities and also joints which are the contraction cracks developed during cooling of the lava. But all the basalt flows do not contain gas cavities and joints and therefore on the basis of presence or absence of gas cavities, basalt flows are grouped into two categories:

i) Vesicular amygdaloidal basalt (Pahoehoe type).
ii) Nonvesicular or compact basalt (aa type).

The two basalt flows have distinct field characters which are described below:

Vesicular-amygdaloidal basalt (compound Pahoehoe) flows are formed by the outpouring of comparatively viscous lava in small quantities through a large number of outlets [18], [19]. Therefore, amygdaloidal basalt flows have small sizes having irregular forms and limited lateral extent. The vesicles are filled with secondary minerals like zeolites, calcite, silica, chlorophaeite etc.
The top surface of amygdaloidal basalt flow is generally reddish in colour. These are also called ropy laves occurring at top.

Compact basalt (aa) flows are thick and extensive having tabular form. In compact basalt flows there is variation in the field characters from its top to bottom. The top surface of compact basalt flow is rather undulating, up to some thickness is hydrothermally altered, purple or greenish colored and vesicular.

The middle and lower portions of compact basalt flows are free from vesicles and amygdules and they occur in true senses as compact basalt. Joints, which are contraction cracks developed during cooling and solidification of the lava, always occur in middle and lower portions of the flow. There is variation in the pattern of jointing and joint spacing. Three types of joints found are closely spaced, broadly spaced and inconsistent non interconnected joints.

Murthy and Jayaram [20] observed seven basalt flows at Hadgaon (Parbhani district) between the elevations of 503 to 385m above msl. The flows vary in average thickness about 18m.

IV. STRUCTURAL FEATURES

Structural features like micro lineaments are recorded in the area from remote sensing studies and the major lineament called Upper Godaveri lineament passing through north of watershed is reported by earlier workers [21] – [24]. There are three mainsheets of micro-lineaments trending in WNW-ESE, ENE-WSW and NW-SE directions (Fig. 2). Murthy and Jayaram [20] reported the micro-lineaments are better repositories of groundwater.

V. GEOMORPHOMETRC ANALYSIS

The main task before geomorphologists is to use an ideal unit of the earth surface for the study of its landforms. The search for an ideal areal unit, within which the collection, processing, organization and interpretation of data of the geometry of landforms, particularly of erosional origin can be made, has been the main aim of the geomorphologists right from [25] - [41].

The river that drains the study area in Jintur is the Karpara, a tributary of Purna River. The drainage network of streams of Dhamuda watershed (Fig.1) shows dendritic to subdendritic and sub parallel.

The dendrite drainage pattern is the network of streams of various orders and magnitudes joining the trunk master streams and resembles the branches of a tree. The development of dendritic to sub dendritic drainage in the watershed indicates the area of massive rock types, gently sloping to almost horizontal terrain and low relief. The sub parallel drainage pattern shows relatively less parallelism than the basic parallel pattern [42]. In Fig.1 the streams show the sub parallel type of drainage pattern. It has been suggested that the parallel drainage in Deccan Basalt terrain is initiated due to the step like nature of the Deccan traps which is joined by subsequent lateral ravines giving a sub-parallel pattern [22].

VI. MORPHOMETRIC ANALYSIS

The morphometric analysis include the assessment of various parameters like bifurcation ratio, length and area ratios, basin configurations, drainage density, stream frequency, length of overland flow and relief aspects (Channel gradient, relief ratio, ruggedness number and hypsometric integrals) of the watershed.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

A. Bifurcation Ratio

The first step in morphometric analysis of watershed is stream order following the method [16]. Accordingly the Dhamuda stream is of fifth order. The ratio of number of stream segments of a given order (Nu) and the number of stream segments of next higher order (Nu + 1) is known as the bifurcation ratio (Rb). The values of bifurcation ratios are between 2.0 and 4.28 (Table 1) indicating that the geological structures do not distort the drainage system [43].

B. Length Ratio

The lengths of the various stream segments were measured order wise and the total lengths as well as the mean stream length for each order were, computed. The length ratio, which is the ratio of the mean length of the streams of a given order to the mean length of the streams of the next lower order, was then calculated for each pair of order (Table 1). The length ratio values found for the watershed are 0.80 to 2.61 indicating the watershed is with normal development of basin and no structural disturbances.

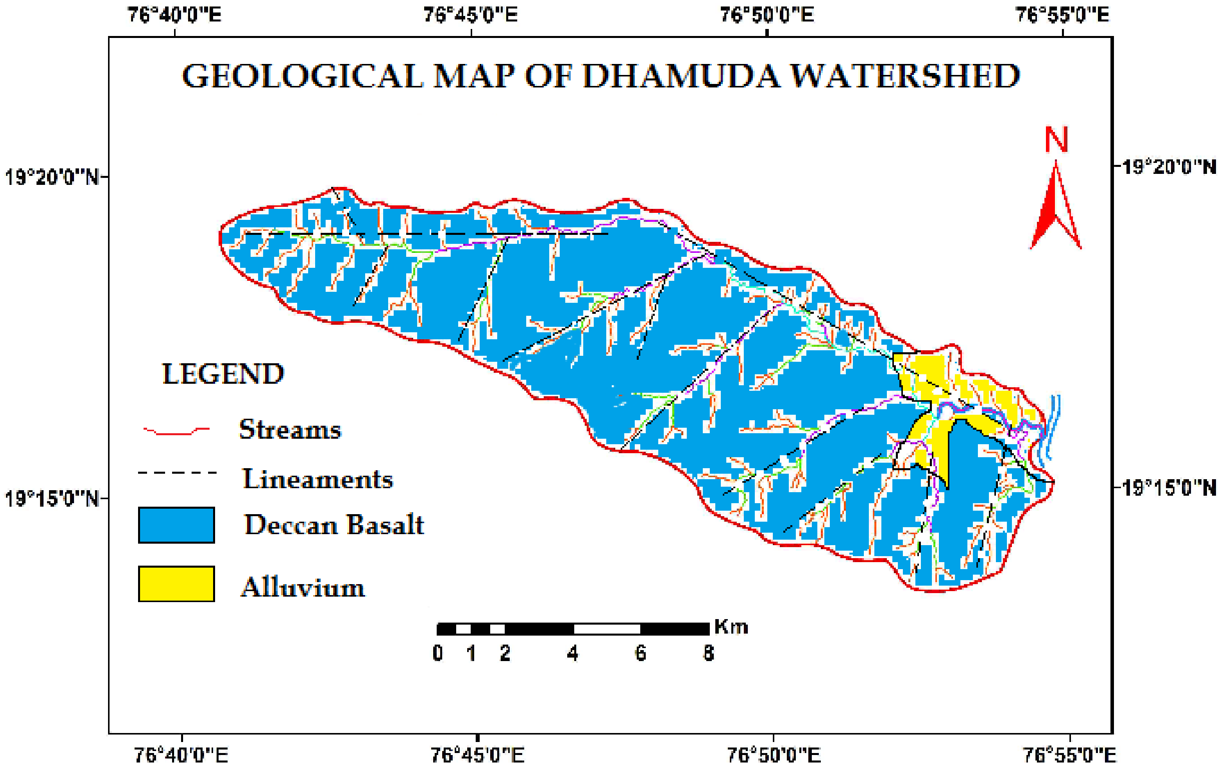

Fig. 2: Geological map of the study area illustrating the lineaments and Deccan basalt formations

C. Basin Configuration

For determining the shape of the drainage basin, a quantitative study of the watershed is made using following three dimensionless ratios:

The form factor (F) suggested by [27] and [44] is the ratio of the basin area to the square of the basin length and the value is 0.20 (Table 2).

The circularity ratio [29] is the ratio of the area of the basin to the area of a circle having the same circumference as the perimeter of the basin. The obtained value is 0.46.

Elongation ratio [31] is the ratio between the diameter of a circle of the same area as the drainage basin and the maximum length of the basin. The value thus obtained is 0.51.

Table 1. Linear aspects of the Dhamuda watershed in Parbhani district

Stream order	No. of streams	Bifurcation Ratio	Stream length (Km)	Mean stream length	Length Ratio
1	107		91.07	0.85	

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

		4.28			1.66
2	25		35.29	1.41	
		3.13			2.61
3	8		29.44	3.68	
		4			1.46
4	2		10.78	5.39	
		2			0.80
5	1		4.30	4.30	

The values of circularity ratio and elongation ratio indicate that the basin is moderately circular and somewhat elongated. The circularity ratio is a significant ratio, which indicates the stages of dissection in the study region. Its value (0.46) can be correlated with the youth stage of the cycle of the erosional development. In comparison with [43] the value of elongation ratio (0.51) suggests that the basin is associated with strong relief and steep ground slope.

D. Drainage Density

Drainage density is defined as the length of streams per unite area [27] and is obtained by dividing the total channel segment lengths (L) by the total area of the basin (A). The drainage density obtained is 1.28 km/km^2 which is moderate value and indicate the watershed of high rate of precipitation and gently sloping to nearly level terrain.

Table 2. Aerial aspects of the Dhamuda watershed in Parbhani district

Sr. No.	Basin Configuration Parameters	Dhamuda Watershed
1	Total stream length-L (Km)	170.89
2	Total basin area-A (Km^2)	133.64
3	Total no. stream-(N)	143
4	Basin perimeter-P (Km)	60.54
5	Maximum basin length - MBL(Km)	25.57
6	Form factor-F	0.20
7	Elongation ratio-E	0.51
8	Circularity ratio-Rc	0.46
9	Drainage density (Km/Km^2)	1.28
10	Stream frequency-(Streams/Km^2)	1.07
11	Highest point on the basin perimeter (m)	431
12	Height of the basin mouth (m)	380
13	Maximum basin relief (H) meters	51
14	Relif ratio – H/MBL	0.002
15	Length of overland flow (L) Km.	0.39
16	Infiltration Number	1.20

E. Stream Frequency

The stream frequency (Fs) refers to the number of streams per unit area [28] and is calculated by dividing the total number of streams (N) by the drainage basin area (A). The stream frequency thus obtained is 1.07 streams/km^2.

The factors affecting the drainage density and stream frequency are the erodibility of the rock and climate. Moderately higher values of drainage density and stream frequency as compared to Purna river basin [45]

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014
reveals that the Dhamuda watershed belongs to the region of high rate of precipitation and gently sloping terrain.

F. Relief (Gradient) Aspects of Watershed

'Charnel gradient' refereed to Strahler (1964) the total drop in elevation from the source to the month is found out for the watershed and the horizontal distances are measured along its length. The value of gradient from this is 10.16 m/km. The profile of the Dhamuda river of the watershed is shown on the google image with the drainage super imposed from the GIS Software (Fig.4.2).

The *'Maximum basin relief'* is the elevation difference between basin mouth and the highest point on the basin perimeter. The calculated value of maximum basin relief is 51m. Using the relief (H), a 'relief ratio' is computed as suggested by Schumm [30], by dividing the relief by maximum measured length of the drainage basin. The value of relief ratio is 0.002.

'*Ruggedness number*' [44] is the product of the basin relief and the drainage density where both terms are in the same unit. The calculated value is 0.065.

The '*Slope of the ground surface*' (Sg) from water divide to stream is obtained by the equation Sg = H x 2D and the value obtained is 0.13 m/km.

The relief measures for Dhamuda watershed are higher i.e. maximum basin relief of 51 m, relief ration of 0.002, ruggedness number 0.065 and slope of the ground surface 0.48 m/km all indicating that the basin lies within hilly terrain and has youth stage of erosional development. The ruggedness number is also indicative of a region of moderate to gently sloping relief.

VII. HYDROGEOLOGY

In Deccan Basalt terrain groundwater occurs under phreatic conditions in the exposed lave flows and under semi confined conditions in the flows at deeper level. Lithological constraints dictate that groundwater is present in the pore spaces of the vesicular basalt and in the jointed and fractured portions of massive parts of the flows. The primary porosity in the basalts is associated with the vesicles, which are the pore spaces developed due to the escape of volatile and gases when the lava erupts on the surface as a lava flow. This primary porosity in the basalt is naturally limited and related to the quantum of gasses/volatile in the eruptive phase, which resulted in the basalt flow. The groundwater in the study area therefore is restricted mostly to the zones of secondary porosity developed in these rocks due to fractures, joints and weathering.

From the hydrogeological point of view, the frequency and extent of jointing, fracturing and the flow contacts and weathering along them are the most significant parameters imparting permeability and porosity for forming suitable groundwater reservoirs in the Deccan Basalt terrain. The vesicular zones occurring in the upper parts of flows or units, though porous, are not permeable, as the vesicles are not interconnected. Secondly, the vesicles are generally filled with amygdules, green earth, glassy material etc. The red bole layer, flow breccia with secondary mineral development and the massive parts of the flow, with non-interconnected joints, are impervious [46], [47]. The secondary porosity (Joints and fractures) generally reduces with depth and hence the near surface (unconfined) aquifer system rarely, extends below 30 m depth [48], [49].

Two distinct types of lava flows have distinct qualities as for as their porosity and permeability are concerned and studied through the well inventory data (Table 3). These are described in detail below:

In amygdaloidal basalt (Pahoehoe type) flow the original gas cavities are filled up with secondary minerals obliterating original vesicular nature. One to presence of amygdules, fresh amygdaloidal basalt is free from joints and occurs as homogeneous, watertight mass [7]. The vesicular amygdaloidal basalt unit (Fig. 4) is more susceptible to weathering and exhibits deep weathering profile. It is characterized by the formation of sheet joints. Such weathered amygdaloidal basalt contains groundwater [50], [51]. However, quantity of groundwater depends upon the thickness of weathered zone.

The compact basalt (aa type) flows can be demarcated into two parts according to their hydro geological characters (Fig. 5). The top portion of this flow is vesicular, unjointed and watertight in fresh condition, but produces sheet jointing due to weathering. The middle and lower parts of the compact basalt flow are jointed. The dug well in jointed compact basalt flow (Fig. 5) shows the jointing pattern. These joints in the compact basalt are closely spaced linear along preferred orientations and the continuity of these joints is traceable over considerable distances. Such fracture zones, which have a discrete distribution in space and orientation, have been reported and described by various researchers [52] – [55]. Such fracture zones transect several Deccan

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014
basaltic units and constitute recharge conduits (lateral as well as down ward transmission of water) for deeper Deccan basaltic aquifers [5]. Sheet joints are also developed at the contact between the vesicular amygdaloidal and the compact basalt that is within the contact zone (Fig. 6). However, quantity of percolation of water depends upon joint spacing and pattern of jointing. Water can percolate through closely spaced joints faster as compared to broadly spaced and non-interconnected joints.

Fig. 3: Drainage map of Dhamuda watershed superimposed on google image

Fig. 4: Dug well showing Amygdaloidal basalt flow at Nandkheda village

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

Fig. 5: Dug well in the Contact basalt Flow at **Fig. 6: Dug well in the Contact basalt** and
Dharmapuri village basalt at Dharmapuri **sheet jointing in amygdaloidal**

VIII. DISCUSSION

The present chapter deals with the discussion on the results of the research work carried out in Dhamuda watershed. It covers the discussion on the aspects of geology, geomorphology and hydrogeology. In geology the field characters of basalt flows and structural features of the area are discussed. Geomorphology deals with reference to the parameters of drainage, morphometric attributes and relief features of the watershed. Impact of geology, geomorphology and climatic conditions on the groundwater fluctuation and water quality are also discussed.

Table 3: Well inventory data of Dhamuda watershed

Sr. No.	Well No.	Village	Diameter (m)	Depth of lining (m)	Type of lining	Depth of Well (m)	Depth of water level (m)	Thickness of litho unit (m)
1	DH1	Dharmapuri	7.4	5.13		26.15	14.00	Lining 5.13 AB 9.87 CB 11.15
2	DH2	Dharmapuri	6.57	10.42	Masonry	10.42	- -	Lining 10.42
3	DH3	Dharmapuri	6.5	9.70	Brick	15.40	13.20	Lining 9.70 CB 6.70
4	DH4	Dharmapuri	5.5	6.25	Concrete	15.20	11.25	Lining 6.25 AB 6.05 CB 2.90
5	DH5	Dharmapuri	5.0	6.0	Brick	11.20	5.0	Lining 6.00 AB 3.20 CB 2.00
6	DH6	Dharmapuri	7.0	4.5	Brick	15.50	11.50	Lining 4.50 AB 5.30 CB 5.70
7	DH7	Dharmapuri	7.6	4.5	Brick	9.00	8.50	Lining 4.50 AB 2.20 CB 2.30
8	DH8	Dharmapuri	7.0	7.5	Concrete	27.70	15.30	Lining 7.50 AB 12.50 CB 7.70
9	DH9	Dharmapuri	6.0	20.3	Brick	30.75	25.23	Lining 20.30 AB 5.45 CB 5.00
10	ND1	Nandkheda	6.0	6.6	Concrete	18.00	15.00	Lining 6.60 AB 5.30 CB 6.10
11	ND2	Nandkheda	5.5	5.0	Concrete	15.00	10.00	Lining 5.00 AB 5.10 CB 4.90

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

12	ND3	Nandkheda	6.5	4.5	Concrete	15.00	10.50	Lining 4.50 AB 5.80 CB 5.70
13	ND4	Nandkheda	9.5	8.25	Brick	12.50	7.50	Lining 8.25 AB 2.25 CB 2.00
14	ND5	Karegaon	5.5	4.5	Concrete	17.00	8.50	Lining 4.50 AB 5.30 CB 7.20
15	ND6	Nandkheda	8.0	8.0	Masonry	22.00	19.50	Lining 8.00 AB 6.30 CB 7.70
16	ND7	Nandkheda	6.0	8.0	Masonry	16.30	16.30	Lining 8.00 AB 4.30 CB 4.00
17	ND8	Nandkheda	8.2	11.0	Masonry	30.00	17.50	Lining 11.00 AB 6.30 CB 12.70
18	ND9	Nandkheda	8.25	4.0	Concrete	20.00	9.00	Lining 4.00 AB 7.30 CB 8.70
19	WD1	Wangi	5.5	5.0	Brick	9.20	9.20	Lining 5.00 AB 2.20 CB 2.00
20	WD2	Wangi	6.2	6.7	Brick	14.00	12.00	Lining 6.70 AB 4.30 CB 3.00
21	WD3	Wangi	5.5	5.5	Concrete	18.00	17.00	Lining 5.50 AB 5.30 CB 7.20
22	WD4	Wangi	1.75	5.0	Masonry	12.20	12.20	Lining 5.00 AB 3.00 CB 4.20

AB: Amygdaloidal Basalt **CB: Compact Basalt**

Stratigraphic division of the lava pile in the study area is not possible on the basis of lithological characters because of the more or less uniform nature of the flows and absence of markers like gaint phenocryst basalt (GPB) flows which help in division and long distance correlation of flow sequence. The maximum thickness of basalt flow is found to be 26m in the northern part of the watershed.

The basalt flows in the study area are classified into two main types namely compact (aa type) and vesicular – amygdaloidal (Compound Pahoehoe type). The 'aa' flow normally consists of a thin vesicular zone on top, thick, massive and dense middle part and a thinner rarely basal clinker (flow breccia). The 'Compound Pahoehoe' flow, on the other hand consists of a series of units in each of which a basal section of pipe vesicles/amygdules, middle massive and dense part and top vesicular part with reddened and glassy crust, with or without ropy structure are seen. The red bole bed (Tachylitic bed) and green bole may occur on the top of compound pahoehoe flows. The 'aa' flows are usually replete with several block joints.

The basalt flows, in general, are broadly horizontal in disposition and exhibit gentle gradients ranging between 1: 100 and 1: 200 in different directions. The marginal area to the northern and northwest of the watershed shows a general southeasterly gradient. The flows range in thickness from 4m to 26m and are essentially of simple type. Several simple flows exhibit fragmentary tops similar to 'aa' [56].

Remote sensing studies show that the area consists of three sets of micro lineament trending directions viz. WNW-ESE, ENE-WSW and NW-SE (Fig. 2). Murthy and Jayaram [20] in the hydrogeological study of Parbhani district reported the lineaments are better repositories of groundwater. There is no significant structural control in the watershed except for a right angle turn and straight courses of stream.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

The drainage network of the area (Fig.1) shows dendritic to sub-dendritic pattern with minor localized variations. The dendritic to sub dendritic drainage pattern occurs over the main basaltic terrain with gentle slopes.

Bifurcation ratios in general have a range from about 2.0 for flat or rolling areas to 3.0 to 5.0 for mountainous, hilly and highly dissected basins [28]. Bifurcation ratio registers very small variation from region to region irrespective of structural control [57]. Strahler [43] found that bifurcation ratio characteristically ranges between 2.0 and 4.28 in watersheds in which the geological structures do not distort the drainage basin. Bifurcation ratios of Dhamuda watershed ranges from 2.0 to 4.28 (Table 1) suggesting the apparently minimal structural control in drainage development. The values of stream length ratios are relatively low (between 0.80 and 2.61, Table 1). The slightly higher values of bifurcation ratio for the lower order streams would mean that the stream has rapid networking of lower order streams resulting in the decrease in mean stream length. This is borne out by the lower values of stream length ratios, which suggests that the area is fairly well dissected and may have gently sloping river valley [58].

The values of form factor (0.20), circularity ratio (0.46) and elongation ratio (0.51) (Table 2) indicates that the watershed is elongated and is in the late mature stage of erosional development. The lower values of drainage density and stream frequency are characteristic of regions of competent and permeable subsurface materials with gently sloping to nearly level terrain relief [43]. In the study area the drainage density (Dd) and stream frequency (Fs) are somewhat lower i.e. Dd = 1.28 km/km^2 and Fs = 1.07 $streams/km^2$, Table 2) which correspond to the rocky, hilly terrain of the watershed with sparse vegetation and impermeable subsurface rocks. The length of overland flow is low for the watershed (0.39 km) indicating the less amount of water is to be run before concentrated in the stream channel. Melton [59] related it with runoff process and concentration of time
The relief measures of the watershed are higher i.e. maximum basin relief is 185m, channel gradient 10.16 m/km, relief ratio 0.002 and ruggedness number 0.065 (Table 2), which also reflect the fact that the watershed lie within hilly terrain. These relief measures also show that the watershed has early maturity stage of erosional development.

In the present study hydrological characters of two distinct lava flows are discussed viz. compact basalt (aa type) and vesicular-amygdaloidal basalt (pahoehoe type) flow. The hydrogeological characters of compact basalt flow depend on the jointing and joint pattern. If the rock is highly jointed/ fractured the water can percolate through these joints and forming the good aquifers. The compact basalt with non-interconnected joints do not hold the water and therefore, are not better aquifers.

The fresh amygdaloidal or vesicular flow is usually free from joints and act as water tight mass. The vesicular – amygdaloidal unit is more susceptible to weathering and exhibits deep weathering profiles. It is also characterised by sheet joints. Such sheet joints and deep weathering are responsible for these units as good aquifers.

IX. CONCLUSION

The area of Dhamuda watershed belongs to Deccan Basalt of Late Cretaceous to Early Eocene period. Field characters of basalt revealed that there are two types of basalt flows viz., vesicular amygdaloidal basalt flow (Pahoehoe type) and compact basalt flow (aa type). Weathered, sheet jointed amygdaloidal basalt and highly jointed compact basalt form the good aquifers. Compact basalt with non-interconnected and inconsistent joints and unweathered amygdaloidal basalt (free from joints) are poor and less yielding aquifers. The Dhamuda stream is a fifth order stream with dendritic, sub-parallel and dendritic with radial-annular enclave drainage pattern. Bifurcation ratio, length ratio and area ratio of streams of the watershed indicate that there is no structural or tectonic control on the drainage development. Morphometric attributes like form factor, circularity ratio and elongation ratio reflects the early mature stage of erosional development. Relief measures also conform the fact that watershed is in early mature stage of erosional development. Slope, channel gradient and ruggedness number is indicative of region with moderate to high relief. By studying the hydro geomorphological conditions of the watershed it is possible to decipher the groundwater potentiality.

ACKNOWLEDGMENT

Student authors gratefully acknowledge the Department of Geology, D.S.M. College, Parbhani and S.R.T.M University, Nanded, Maharashtra, India for assigning the projects to the students of Under Graduate level.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 4, July 2014

REFERENCES

[1] Adyalkar, P.G., Ayyangar, R.S., Tikekar, S.S. and Khare, Y.D. Groundwater potential of Deccan Flood Basalt of Nagpur District in Maharashtra : An imprint derived from satellite imagery In Deccan basalt, Gondwana Geol. Soc. Sp. Vol. 2, pp. 485-492, 1996.

[2] Babar, Md. Geological and Geomorphological Mapping of Akoli watershed in Jintur Tahsil of Parbhani district, Maharashtra. Indian J. of Geomorphology, Vol. 8 No. 1&2, pp. 87-94, 2003.

[3] Babar Md.and I.I. Shah. Remote Sensing and GIS Application for Groundwater Potential Zones in Tawarja River Sub-Basin, Latur District, Maharashtra, India. International Journal of Earth Sciences and Engineering (IJEE), Vol. 4 (3) Spl. issue, May 2011, pp. 71-79, 2011.

[4] Bhagavan, S.V. B.K. Remote sensing techniques for watershed programmes in Andhra Pradesh. Proc. Of workshop on water shed management problems and prospects (WmPP98), Centre for water Resources, J.N. Technological Univ., Hyderabad, pp. 24-33, 1998.

[5] Kulkarni, H., Deolankar, S.B., Lalwani, A. and Lele, V.A. Integrated remote sensing as an operational aid in hydrogeological studies of Deccan basalt aquifer. Asian-pacific remote sensing J. (ESCAP), Vol. 6(12), pp. 9-18, 1994.

[6] Muley R.B., Babar Md. and Ghute B.B. Geomorphological and Hydrogeological Studies of Borna Macro-Watershed, Parbhani and Beed District, Maharashtra. Gondwana Geological Magazine, Spl. Vol. 14, pp. 71-75, 2014.

[7] Patil, B.S., Khadilkar, A.K. and Zambre, M.K. Shallow groundwater zones mapping by using remote sensing techniques: A case study around Pishore, Aurangabad district, Maharashtra. In Seminar Vol. on “Groundwater and watershed development” at Dhule, pp. 63-65, 1999.

[8] Srinivasa Rao, Y., Krishna Raddy, T.V. and Nayudu, P.T. Hydrogeomorphological studies by remote sensing Application in Niva River basin, Chittor District, Andhra Pradesh. Photonirvachak (J. Indian Soc. Rem. Sensing), Vol. 25(3), pp. 187-194, 1997.

[9] Raju, K.C.B., Rao, G.V.K. and Kumar, B.J. Analytical Aspects of remote sensing techniques for ground water prospecting in hard rocks. Proc. Sixth Asian Conference on remote sensing, pp.127-132, 1985.

[10] Satyanarayana, R. Remote sensing studies on the land and water resources of Hyderabad City and environs. Ph.D. Thesis, S.V. Univ. Tirupati, India (Unpublished), 1991.

[11] Palanivel, S., Ganesh, A. and Vasantha Kumaran, T. Geohydrological evaluation of upper Agniar and Vellar Basins, Tamilnadu: An integrated approach using Remote sensing, Geophysical and well inventory data. J. Indian Soc. Rem. Sensing. Vol. 24 (3), pp153-168, 1996.

[12] Babar, Md. Hydrogeomorphological mapping for groundwater resource development in the northern part of Parbhani District (Maharashtra) using IRS 1B, LISS II Geocoded data. In proceeding volume of National conference on GIS and Their Application in Civil Engineering during February 14-16 2002 at Deccan College of Engineering and Technology, Hyderabad, pp.75-83, 2002.

[13] Babar Md. Remote Sensing and GIS Applications in Groundwater Targeting for Rural Development at Akoli Watershed area, Maharashtra. Proceeding vol. National Seminar on GIS application for Rural Development at NIRD, Hyderabad, pp.204-213, 2005.

[14] Babar Md. Application of Remote sensing and GIS in Watershed Development of Deccan Trap Basalt. Proceeding volume of National conference held at Deogiri College, Aurangabad, pp. 53-57, 2009.

[15] Babar Md., B.B. Ghute and R.V. Chunchekar. Application of Remote Sensing, Geomorphological and Hydrogeological Studies for Groundwater Potential Of Indrayani Nala Macro-Watershed In Parbhani District, Maharashtra. Advanced Journal of Geographical World (AJGW), Vol.1 (1), pp. 46-51, 2011.

[16] Strahler, A.N. Quantitative analysis of watershed geomorphology. Tans. Am. Geophys. Union, Vol. 38, p.931, 1957.

[17] Godbole, S.M., Rana, R.S. and Natu, S.R. Lava stratigraphy of Deccan basalts of Western Maharashtra. Gondwana Geo.Mag., Spl. Vol. 2, pp. 125-134, 1996.

[18] Gupte, R.B. Engineering aspects of Deccan Trap Basalt, Maharashtra Public work Journal Vol. 7(3-4), pp. 7-20, 1971.

[19] Kulkarni, S.R., Karmarkar, B.N. and Gupte, R.B. Variation in the nature of Deccan trap volcanicity of western Maharashtra in time and space. Memoir Geol. Soc. India, No.3, pp. 143-152, 1980.

[20] Murthy, K.N. and Jayaram, K.M. Groundwater resources and development potential of Parbhani district, Maharashtra, C.G.W.B Report on Annual Action Programme (1995-96). 702/DIS/96, Nagpur, pp. 1-39, 1996.

[21] Rajurkar, S.T., Bhate, V.D. and Sharma, S.B. Lineament fabric of Madhya Pradesh and Maharashtra and its tectonic significance. GSI Spl. Pub. No. 28, pp. 241-259, 1990.

[22] Dhokrikar, B.G. Groundwater resources development in basaltic rock terrain of Maharashtra, (edited by B.G.Dhokrikar) Water Industry Publ., Pune, pp. 122-185, 1991.

[23] MRSAC. Maharashtra Remote Sensing Application Centre. Dept. of planning, Govt. of Maharashtra, Nagpur. Unpublished Geomorphologic map of Parbhani district, 1992.

[24] Joshi, A.K., Jayaram, A., Krishna Murthy, Y.V.N. and Srinivasan, D.S. Integrated geological study of Deccan Trap province of Maharashtra and adjoining parts. Gondwana Geol. Magz., Spl. Vol. 2, pp. 461 – 466, 1996.

[25] Easterbrook, D.J. Principles of geomorphology. Edited by D.J.Easterbrook, McGraw Hill; New York, pp. 1-46, 1969.

[26] Fennaman, N.M. Physiographic boundaries within the United States, Ann. Asson. Amer. Geogr. Vol. 4, pp. 84 – 134, 1914.

[27] Horton, R.E. Drainage basin characteristics. Trans. Amer. Geophys. Un. pp. 350- 361, 1932.

[28] Horton, R.E. Erosional development of streams and their drainage basins: Hydro physical approach to Quantitative morphology. Bull. Geol. Soc. Am. Vol. 56, pp. 275-370, 1945.

[29] Miller, V.C. A Quantitative geomorphic study of drainage basin characteristics in Clinch Mt. Area Virginia and Tennessec. Tech.. Rep. No.3, Dept. Geog. Columbia Univ., New York, Contract N6 ONR 271-030, pp. 1-30, 1953.

[30] Strahler, A.N. Quantitative slope analysis. Geol. Soc. Am. Bull. 67 (5), pp. 571-596, 1956.

[31] Schumm, S.A. The evolution of drainage systems and slopes in bad lands at Perth, Amboi, New Jersey. Geol. Soc. Ame. Bull. 67 (5), pp. 597-646, 1956.

[32] Chorley, R.J. Climate and morphometry. J.Geol. Vol.65, pp.628-638, 1957.

[33] Shreve, R.L. Statistical law of stream numbers. J.Geol. Vol. 74 (1), pp. 17-37, 1966.

[34] Sarkar, A. Morphometric identity of Topologically Distinct Channel Network Basin: A case study of Lodhan Khola basin, Darjeeling Himalayas. Indian J. Geology, Vol. 67 (2), pp. 142-150, 1995.

[35] Dumout, J.F., Mering, C., Parrot, J.F. and Tund, H. Morphological and mathematical analysis of asymmetrical fluvial pattern: A study case from the Vcayali River (Peru). Z. Geomorph. N.F. Suppl. Ed. 103, pp. 269-282, 1996.

[36] Crave, A. and Davy, P. Scaling relationships of channel networks at large scales: Examples from two large magnitude watersheds in Brittany,France. Tectonophysics, Vol.269, pp.91-111, 1997.

[37] Iqbaluddin, Saif Uddin and Akram Javed. Geomorphology and landscape evolution of Bharatpur district, Rajasthan. J. Indian Soc. Remote Sensing, Vol. 25(3), pp. 177-186, 1997.

[38] Babar, Md. and Kaplay, R.D. Geomorphometric analysis of Purna River basin Parbhani District (Maharashtra). Indian J. of Geomorphology, Vol-3 No.1, pp.29-39, 1998.

[39] Lekach, J., Amit, R., Grodek, T. and Schick, A.P. Fluvio-pedogenic processes in an ephemeral stream channel, Nahal Yeel, Southern Negav, Israel. J. Geomorphology, Vol.23 (2-4), pp. 353-369, 1998.

[40] Raj, R., Maurya, D.M. and Chamyal, L.S. Evolution of Mahi drainage basin during Quaternary: A morphometric approach. Gondwana Geol. Magz. Spl. Vol. 4, pp. 131-139, 1999.

[41] Babar, Md. Quaternary Geology and Geomorphology of Purna River sub-basin of Godavari River Basin, Maharashtra, India. Gondwana Geol. Magz. Vol. 23 (1), pp.81 – 90, 2008.

[42] Zernitz, E.R. Drainage patterns and their significance. J. Geol. Vol. 40, pp. 498-521, 1932.

[43] Strahler, A.N. Quantitative geomorphology of drainage basin and channel networks. In : Handbook of Applied Hydrology (edited by V.T.Chow), pp. 4.39-4.76, 1964.

[44] Strahler, A.N. Quantitative geomorphology. In: Fairbridge, R.W. (ed). The Encyclopedia of geomorphology, Reinhold Book Crop. New York, 1968.

[45] Babar, Md. Geomorphometric analysis of Purna river basin in Parbhani district (Maharashtra) India. Indian J. Geomorphology Vol. 3(1), pp. 29-39, 1998.

[46] Muley R.B., Babar, Md., Atkore S.M. and Ghute B.B. Impact of Geology on Groundwater and Water Harvesting Structures in Deccan Basalt Area: A Case Study of Jhari Percolation Tank in Parbhani District, Maharashtra. Journal of Advances in Science and Technology, Vol. 13 (1), pp. 96-101, 2010a.

[47] Thorat, P.K. and Sable, A.B. Importance of the Geological Mapping in selection of sites for artificial recharge in the Deccan Volcanics with reference to some case histories from Parmer Taluka of Ahmednagar Dist., Maharashtra. In Seminar Vol. On “Modern Techniques of rainwater harvesting, water conservation and artificial drinking water a

forestation, horticulture and agriculture", pp. 199-239, 1990.

[48] Agashe, R.M. Scope for artificial groundwater recharge in Deccan trap areas of Maharashtra – an over view. Proec All India Seminar on modern Techniques of Rain water harvesting, water conservation and artificial recharge for Drinking water, a forestation horticulture and Agriculture. Pune, G.S.D.A. Publ. pp.121-192, 1990.

[49] Muley R.B., Kulkarni P.S. and Md. Babar. Hydrogeological Studies of Mendhwan Watershed Ahmadnagar District Maharashtra, India. Advances in Geosciences, Vol.23 Hydrological Science, 237-246, 2010b.

[50] Lawrence, A.R. An interpretation of dug well performance using a digital model. Groundwater, Vol. 23(4), pp. 449-454, 1985.

[51] Kulkarni, H. and Deolankar, S.B. Hydrogeological mapping in the Deccan Basalt-An appraisal J. Geol. Soc. Indian Vol. 46(4) , pp. 345-352, 1995.

[52] Peshwa, V.V., Mulay, J.G. and Kale V.S. Fracture zone in the Deccan traps of western and central India: A study based on remote sensing Techniques, Photonirvachak (J. Indian Soc. Rem. Sensing) , Vol. 15(1), pp 9-17, 1987.

[53] Powar, K.B. Lineament fabric and Dyke patterns in the western part of the Deccan volcanic province. Mem Geol. Soc. India, vol. 3, pp. 45-57, 1981.

[54] Kale, V.S. and Kulkarni, H. IRS-1A and LANDSAT data in mapping Deccan Trap flows around Pune : Implications on hydrogeological modeling. Archives. Int. Soc. Photogramm and Rem. Sens. , Vol. 29 , pp429-435, 1992.

[55] Kulkarni H. Delineation of shallow Deccan basaltic aquifers from Maharashtra, using aerial photo interpretation. Photonirvachak (J. Indian Soc. Rem. Sensing), Vol. 20 (2&3) , pp 129-138, 1992.

[56] Deshmukh, S.S. Geology, Petrography and Petrochemsitry of the Deccan basalts in parts of Maharashtra state. Unpublished progress report of G.S.I., CR, Nagpur, 1980.

[57] Singh savindra, Ojha, S.S. and Agnihotri, S.P. On the regional variations in bifurcation ratios. In: Geomorphological Mosaic, edited by S.C. Mukhopadhyay, Calcutta Univ., pp. 203-210, 1984.

[58] Badve, R.M., Mehta, S. Sonar, M. and Deshmukh, B.P. Intensive horticulture for the drought prone areas – A case study. Proc. Vol. Of seminar on "Modern techniques of rainwater harvesting, water conservation and artificial recharge for drinking water, afforestation, horticulture and agriculture", pp. 608-615, 1990.

[59] Melton, M.A. An analysis of the relation among elements of climate, surface properties and geomorphology. Off. Nav. Res. (U.S.), Geogr. Branch, Project 389-042, Tech. Rep., 11, p. 102, 1957.