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Morphometric Analysis Of Bhogavati River Basin, Kolhapur District, Maharashtra, India.

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***ABSTRACT*:** *Watershed development and management plans are very important for surface and ground water conservation. To prepare a watershed development plan, it becomes important to know the topography, lithology, erosional status and drainage pattern of the area. In the present investigation various morphometric parameters of the Bhogavati river basin are outlined. The Bhogavati river basin is 5th order and its different morphometrical parameters are found to be useful for the proper land use planning and water resources management studies in the basin. Dendritic drainage pattern in the area shows that the area consists of homogeneous rock material, which is structurally undisturbed. The Basin is passing through an early mature stage to old stage of the fluvial geomorphic cycle. The elongation and circulatory ratio reveals that the Bhogavati river basin is highly elongated and flood flows are easier to manage than that of circulatory basins.*
Keywords *- Basin, Bhogavati, Morphometric, Parameters, River.*

1. 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 infiltration of water with time depends on morphometric parameters of any catchment area (Sawant, 2002). Therefore it is necessary to use advanced techniques for harvesting and conservation of water resources.

The morphometric characteristics of various basins have been studied by various scientists using conventional methods (Horton, 1945; Smith, 1950; Strahler, 1964). The morphometric parameters have been used in various studies of geomorphology and surface water hydrology, such as flood characteristics, sediment yield and evolution of basin morphology. The watershed management studies have a special importance in the field of research, due to the increasing demand of water. Pawar and Raskar, (2011) has carried out morphometric analysis of Panchaganga river basin of Kolhapur district. Yadav and Sawant, (2011) has carried out morphometrical parameter estimation of Sheri Nala basin, Sangli district. Jangle and Patil, (2010) has done morphometrical parameter estimation of Nalganga river, Buldhana, Maharashtra. Nageswara and et. al., (2010) has carried out morphometric analysis of Gostani river basin in Andhra Pradesh.

2. STUDY AREA

The Bhogavati river basin bounded between latitude $16^0$19’45’’N to $16^0$44’30’’N and longitude $73^0$50’15’’E to $74^0$11’50’’E in Survey of India Toposheet numbers 47 H/15, 47 L/2 and 47 L/3 and having area of about 440.5 km^2 (Fig. 1). The Bhogavati river is one of the major tributary of the Panchaganga river and Panchaganga river is a tributary of river Krishna. The study area is covered by Deccan volcanic basalt of Upper Cretaceous to Lower Eocene age. The soil cover of the study area is fertile and important for agriculture purpose. The climate of the area comes across as an amusing blend of the coastal and inland climate of Maharashtra. The temperature between 10^0C and 40^0C. The average annual rainfall of the area is 4,800 mm. The Bhogavati river basin shows well developed dendritic to sub dendritic type drainage pattern. (Fig. 2). In the present paper the authors had made an attempt to morphometric analysis of Bhogavati river basin.

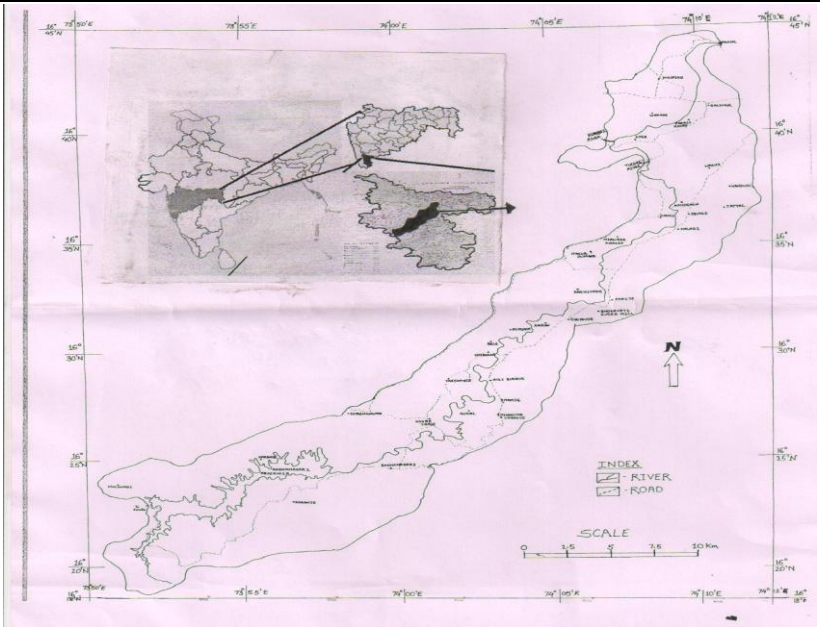

Figure 1 : Location Map of the Study Area

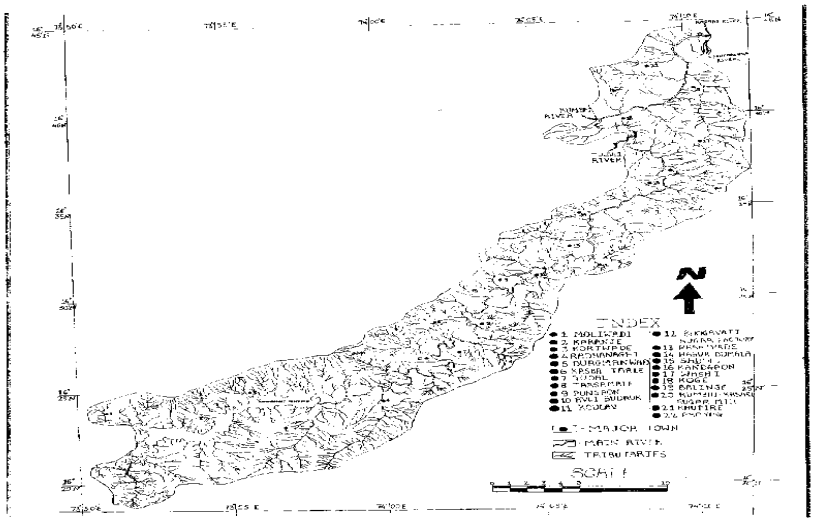

Figure 2 : Drainage map of the Study area

3. METHODOLOGY

The Survey of India Toposheet numbers 47 L/2, 47L/3 and 47H/15, on the scale of 1 : 50,000 were used for the present study. Stream ordering method as suggested by the Strahler has been employed. The different morphometric parameters have been calaculated by using formulae. For stream ordering method suggested by Strahler (1957) has been used.

4. RESULTS AND DISCUSSION

The drainage characteristics of Bhogavati river basin have been examined with reference to linear, aerial and relief aspects.

4.1. Linear Morphometric Aspects

4.1.1. Stream Order (u)

Stream order of drainage basin is the successive assimilation of the streams within a drainage basin. The ordering of the basin have been carried out by the method suggested by Strahler (1957). The Bhogavati river basin is 5th. (Table 1)

4.1.2. Stream Number (Nu)

After assigning stream orders, the segments of each order are counted to get the number of segments of the given order (u). Individual counting of the streams in the river basin reveals the total number of the streams. Whole Bhogavati river basin has 1506 streams, of which 77.5% are the first order streams having 1167 segments. The second order stream segments are 270 and account for 17.9%, third order stream segments are 57 and accounted 3.8%, fourth order stream segments are 11 and account for 0.73% and fifth order stream segment is 1 and account for 0.07%. (Table 1). The logarithm of stream length of each order as a function of order is plotted and yields a set of points lying generally along a straight line (Fig. 3). Relation between stream order (u) and stream numbers (Nu) shows the straight line which indicate area without structural disturbance (Fig. 4).

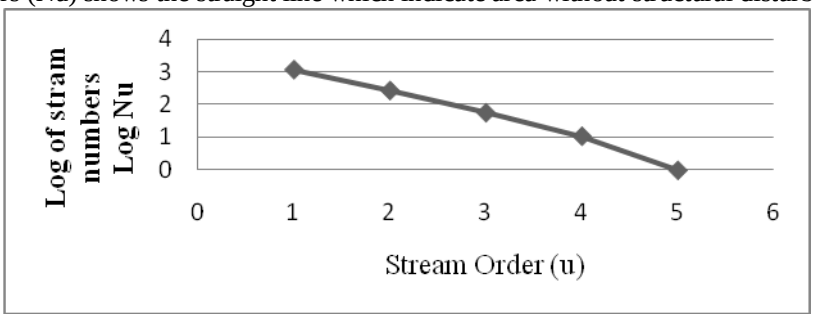

Figure 3 : Regression of logarithm of Number of streams Vs. Stream Order

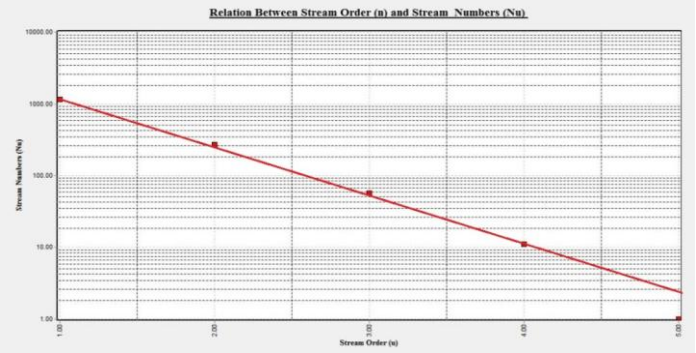

Figure 4: Relation between Stream Order (u) and Stream Numbers (Nu)

4.1.3. Bifurcation Ratio (Rb)

It is the ratio of number of streams of any given order to the number of streams in the next lower order (Horton, 1945).

$$Rb = \frac{Nu}{Nu+1} \quad (1)$$

The significance of this ratio is that as the ratio is reduced so the risk of flooding within the basin increases. it also indicates the flood risk for parts of the basin. In the Bhogavati river basin bifurcation ratio ranges from 4.32 to 11. The mean bifurcation ratio for Bhogavati river basin is 6.31. This means that on an average, there are 6.31 times as many channel segments to any given order as of the next higher order. The average bifurcation ratio of the basin reveals that there appears to be no strong geological control in the development of the drainage, homogeneous nature of lithology and drainage network in study area is well developed stage. (Table 1)

4.1.4. Stream Length (Lu)

Study of the stream length with respect to the stream order is of significant importance. Stream length for the basin of the given order is inversely proportional to the stream order. Stream length of the basin indicate surface runoff characteristics. Streams of relatively smaller lengths are characteristics of area with greater slopes. Stream length of Bhogavati river and its tributaries is measured with the help of rotometer. The total stream length in Bhogavati river basin is 1054 km. (Table 1). The mean length of channel Lu of order U is the ratio of the total length to the number of streams of a given order. Mean length of channel segments of a given order is greater than that of the next lower order but less than that of the next higher order. The logarithm of stream length of each order as a function of order is plotted (Fig. 4) and relation between stream order (u) and mean

stream length (Fig. 5), yields a set of points lying generally along a straight line, that indicates no strong structural control in the area. (Geena, 2011).,

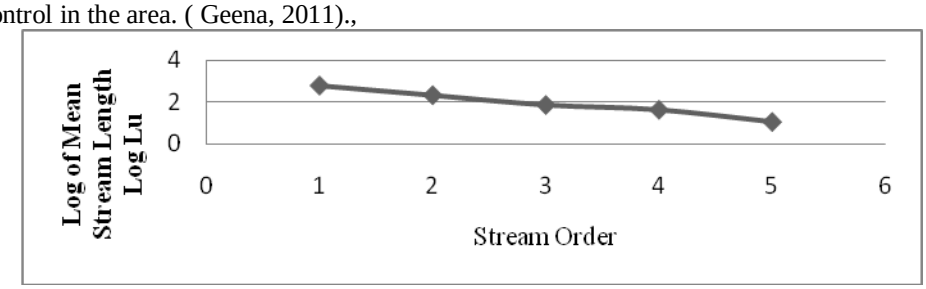

Figure 4: Regression of logarithm of Mean Stream Length Vs. Stream Order

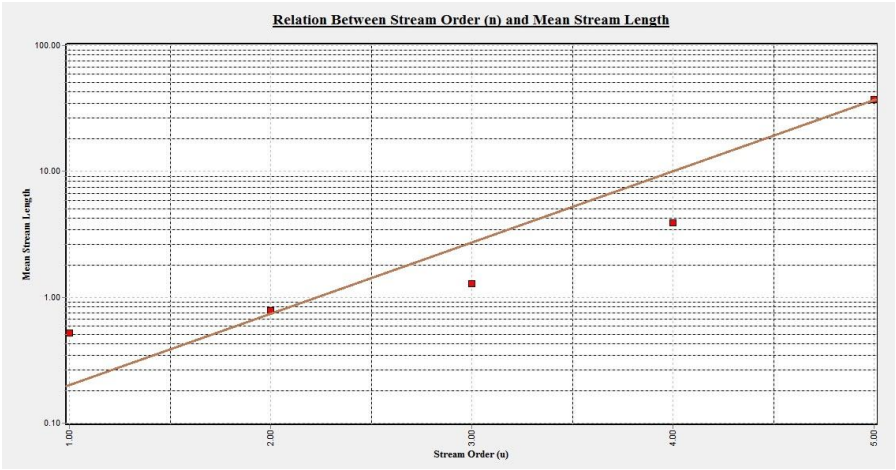

Figure 5 : Relation between Stream Order (u) and Mean Stream Length (Nu)

4.1.5. Stream Length Ratio (R*l*)

The ratio in between the average lengths of successive orders is stream length ratio. (Horton, 1945). In the southern half part of basin large number of small streams are developed where the formations at upstream side and are less permeable (Manu, 2008). Stream length ratio of Bhogavati river basin is given in Table 1.

4.2. Aerial Aspects of Drainage Basin

4.2.1. Basin Area (A)

Basin area is the direct outcome of the drainage development in a particular basin. The area of Bhogavati river basin is about 440.5 sq. km. which indicates that rainwater will reach the main channel more rapidly, where the water has much further to travel.

4.2.2. Drainage Density (Dd)

Drainage density is defined as a ratio of total length of all streams to the total area of the basin. (Horton, 1932).

$$Dd = \frac{Lu}{A} \quad (2)$$

Drainage density of the any basin reveals the terrain configuration that is properties of rock of the area. In the study area southern half part of basin shows high drainage density which indicates region having non resistant or impermeable subsurface material and mountainous relief, whereas northern half part of basin shows low drainage density which indicates region having highly resistant rock or highly permeable subsoil material and area with low relief. (Geena, 2011). The overall drainage density (Dd) of the Bhogavati river basin is 2,20 km/sq.km (Table 2)

4.2.3. Stream Frequency (Fs)

The stream frequency of the basin is the ratio of total number of stream segments of all orders to the basin area. (Horton, 1945)

$$Fs = \frac{Nu}{A} \quad (3)$$

It is a good indicator of drainage pattern. Stream frequency has been calculated by the number of streams divided by the total area of basin in sq. km. The stream frequency value of the Bhogavati river basin is 3.42.

High drainage density and high stream frequency in Bhogavati river basin indicate larger runoff from the basin. (Table 2)

4.2.4. Constant of Channel Maintenance (C)

The Constant of Channel Maintenance is the inverse of the drainage density. (Schumm, 1956). Therefore higher the drainage density lowers the constant of channel maintenance and vice versa. In the southern half part of the basin the value of Constant of channel maintenance is very low which indicate that only rocks are relatively impermeable or terrain is very steep. But in the northern half part of the basin the value of Constant of channel maintenance is relatively high which indicate the presence of little more permeable overlying material than southern part of the basin. Regarding the Bhogavati river basin, the average constant of channel maintenance is 0.42 (Table 2)

4.2.5. Texture Ratio (Rt)

It is the ratio of total stream numbers to the total perimeter of the basin (Horton, 1945).

$$Rt = \frac{Nu}{P} \quad (4)$$

Texture ratio is an important factor in the drainage morphometric analysis which is depending up on the underlying lithology, infiltration capacity and relief aspect of the terrain (Nageswara, 2010). Smith (1950) has classified drainage density into five different texture i.e. very coarse (<2), Coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). In the present study texture ratio of the Bhogavati river basin is 7.62, which indicate fine texture and area under high relief and steep slopes. (Table 2)

4.2.6. Elongation Ratio (Re)

Elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length (Schumm, 1956).

$$Re = \frac{2\sqrt{\frac{A}{\pi}}}{Lb} \quad (5)$$

It is the very significant index in the analysis of basin shape which helps to give an idea about hydrological characters of a drainage basin. The value of elongation ratio (Re) generally varies from 0.6 to 1.0 associated with a wide variety of climate and geology. Values close to 1.0 are typical of regions of very low relief whereas that of 0.6 to 0.8 are associated with high relief and steep ground slope (Strahler, 1964). These values can be grouped into three categories, namely circular (>0.9), oval (09-0.8) and elongated (< 0.7).The Elongation ratio of the Bhogavati river basin is 0.27 which indicate basin is highly elongated. (Table 2)

4.2.7. Circulatory Ratio (Rc)

Circulatory ratio is the ratio of basin area to the area of circle having the same perimeter as the basin (Miller, 1953).

$$Rc = \frac{4\pi A}{P^2} \quad (6)$$

It is influenced more by the length, frequency and gradient of streams of various orders than slope conditions and drainage pattern of the basins (Strahler, 1957). Circulatory ratio of Bhogavati river basin is 0.24 which is below 0.5 and shows strongly elongated basin with semi permeable homogeneous lithology. (Table 2)

4.2.8. Form Factor Ratio (Rf)

Form Factor Ratio is the dimensionless ratio of the basin area to the square of basin length (Horton, 1932).

$$Rf = \frac{A}{Lb^2} \quad (7)$$

The Form Factor Ratio value of the Bhogavati river basin is 0.057 which is very nearer to zero and thus represents highly elongated in shape. In this elongated basin with low form factor will have a flatter peak flow of longer duration. Flood flows in elongated basins are easier to manage than that of the circular basins (Geena, 2011). (Table 2)

4.3. Relief Aspects of Drainage Basin

4.3.1. Basin Relief (H)

The vertical distance difference between point of maximum elevation and minimum elevation is the relief of basin. The basin relief of Bhogavati river is 477 meters. (Table 3)

4.3.2. Relief Ratio (Rh)

When basin relief (H) is divided by maximum basin length (Lb) gives the relief ratio (Schumm, 1954). The relief ratio of Bhogavati river basin is 0.005, which indicates that the basin has strong relief and steep slope. Other sub-basins also show high values, because most of the sub-basins are located above 600 m above msl. The higher stream frequency values show that the permeability of rocks is less at upstream to the middle portion of the basin. Here the infiltration is mainly through fractures and joints, which are the extension of the surface joints. But the permeability of rocks increases towards downstream side where the rocks are weathered. (Table 3)

4.3.3. Ruggedness Number (Rn)

Ruggedness number is the product relief of basin (H) and drainage density (Dd). The ruggedness number of Bhogavati river basin is 1049.5 which indicate both relief and drainage density are high. Such higher values are expected in a mountainous region of tropical and sub-tropical climate with higher rainfall (Schumm, 1956). (Table 3)

Table 1. Linear aspects of the drainage network of the study area.

River Basin	Stream Order (u)	Number of Streams (Nu)	Total length of streams in km (Lu)	Mean Stream Lengths	Stream Length Ratio (R*l*)	Log Nu	Log Lu
Bhogavati	1	1167	606	0.52	-	3.067	2.782
	2	270	212	0.78	1.5	2.431	2.326
	3	57	73	1.28	1.64	1.755	1.863
	4	11	43	3.90	3.05	1.041	1.633
	5	01	37.5	37.5	9.61	0	1.057
Total		1506	971.5				
Bifurcation Ratio (Rb)							
1^{st} Order / 2^{nd} Order	2^{nd} Order / 3^{rd} Order	3^{rd} Order / 4^{th} Order	4^{th} Order / 5^{th} Order	**Mean Bifurcation Ratio**			
4.322	4.736	5.18	11	6.309			

Table 2. Aerial Aspects of the drainage network of the study area.

Morphometric Parameters	Symbol / Formula	Calculated Value
Area (sq. km)	A	440.5
Perimeter (km)	P	153
Drainage Density	$Dd = \frac{Lu}{A}$	2.20
Stream Frequency	$Fs = \frac{Nu}{A}$	3.42
Texture Ratio	$Rt = \frac{N_1}{P}$	7.62
Basin Length (km)	Lb	87.5
Elongation Ratio	$Re = \frac{2\sqrt{\frac{A}{\pi}}}{Lb}$	0.27
Circulatory Ratio	$Rc = \frac{4\pi A}{P^2}$	0.24
Form Factor Ratio	$Rf = \frac{A}{Lb^2}$	0.057
Constant of Channel Maintenance	$C = \frac{1}{Dd}$	0.42

Where, Lu = Total Stream length of all orders.
Nu = Total number of streams of all orders
N_1 = Total number of 1st order streams.
Π = 3.14

Table 3. Relief aspects of drainage network of study area

Morphometric Parameters	Symbol / Formula	Calculated Value
Maximum elevation in the area (mts.)		1017
Minimum elevation in the area (mts.)		540
Basin Relief (mts.)	H = Max. Elevation – Min. Elevation	477
Relief Ratio (Rh)	$Rh = \frac{H}{Lb}$	0.005
Ruggedness Number (Rn)	$Rn = H\ X\ Dd$	1049.5

5. CONCLUSION

The morphometric study of Bhogavati river indicates that the basin is fifth order basin and is passing through an early mature stage to old stage of the fluvial geomorphic cycle. The basin shows dendritic type drainage pattern. Mean length of channel segments of a given order is greater than that of the next lower order but less than that of the next higher order. The logarithm of stream length of each order as a function of order is plotted and relation between stream order and mean stream length, yields a set of points lying generally along a straight line, that indicates no strong structural control in the area. The average bifurcation ratio of the basin reveals that there appears to be no strong geological control in the development of the drainage, homogeneous nature of lithology and drainage network in study area is well developed stage. The southern half part of the basin is under high relief which shows steep slopes with high drainage density, high stream frequency, low constant of channel maintanence and less permeable subsurface lithology. The northern half part of the basin is under low relief as compare to the southern part which shows gentle slopes with low drainage density, low stream frequency, high constant of channel maintenance and highly permeable subsurface lithology. The elongation ratio, circulatory ratio and form factor reveals that the Bhogavati river basin is highly elongated and flood flows are easier to manage than that of circulatory basins. The study also reveals that the texture of Bhogavati river basin is very fine and basin is highly elongated. The drainage basin size analysis reveals that the flooding is lesser.

6. Acknowledgements

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