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Morphometric Analysis of Pat River Basin in around Kajlidongri Area, Meghnagar Block, Jhabua District, Madhya Pradesh, India

***Vinod Bhuriya[1], Dilip Dixit[2]**

Author's Affiliations:
[1]Department of Geology, Govt. Adarsh College Shahpura, Dindori, Madhya Pradesh 481990, India.
[2]GIS Cell under Data Resource Center, DGMH, Lucknow, Uttar Pradesh 226001, India.

***Corresponding Author: Dr. Vinod Bhuriya,** Department of Geology, Govt. Adarsh College Shahpura, Dindori, Madhya Pradesh 481990, India.
E-mail: drvinodbhuriyageo@gmail.com

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ABSTRACT

Morphometric Analysis of Pat River Basin in around Kajlidongri area, Meghnagar Block, Jhabua District, Madhya Pradesh, India, has been carried out with main purpose to recognize the characteristics of drainage basin. The morphometric analysis of Pat River basin in around Kajlidongri area, covering an area of 68 km². The Pat River drainage basin is divided into six sub-basins A, B, C, D, E and F. The outcome of linear, areal and relief parameters recognized a good variation range and their importance have been discussed. The result of morphometric analysis would be helpful in determining the recharge zone, permeability of sub-basin area, groundwater potential sites and evolution of the Pat River drainage basin characteristics plays a significant role in the development of groundwater resources in the study area.

KEYWORDS: *Morphometric Analysis, Pat River Basin, Kajlidongri, Meghnagar Block, Jhabua District, Madhya Pradesh, India.*

INTRODUCTION

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Clarke, 1966). Geomorphological analysis of Pat River basin in around Kajlidongri area, Meghnagar Block located in Jhabua District of Madhya Pradesh, India for the determining the groundwater potential zones, geological structure, geomorphological features and topographical characteristics.

STUDY AREA

The examined study area is enclosed between latitudes 22°55′ to 23°0′N and longitudes 74° 25′ to 74°30′E, covering an area of 68 km² (Survey of India toposheet no. 46 J/5, Figure 1) on 1: 50,000 scale. The climate of study area is tropical Monsoon type. The temperature ranges from 3.5°C to 43.5°C. Normally the study area is comparatively dry. Maximum relative humidity is about 34.4 to 50% during months of July, August, September and the minimum 20 to 30% during months of February to May. The average rainfall of the Meghnagar study area is 889.508 mm.

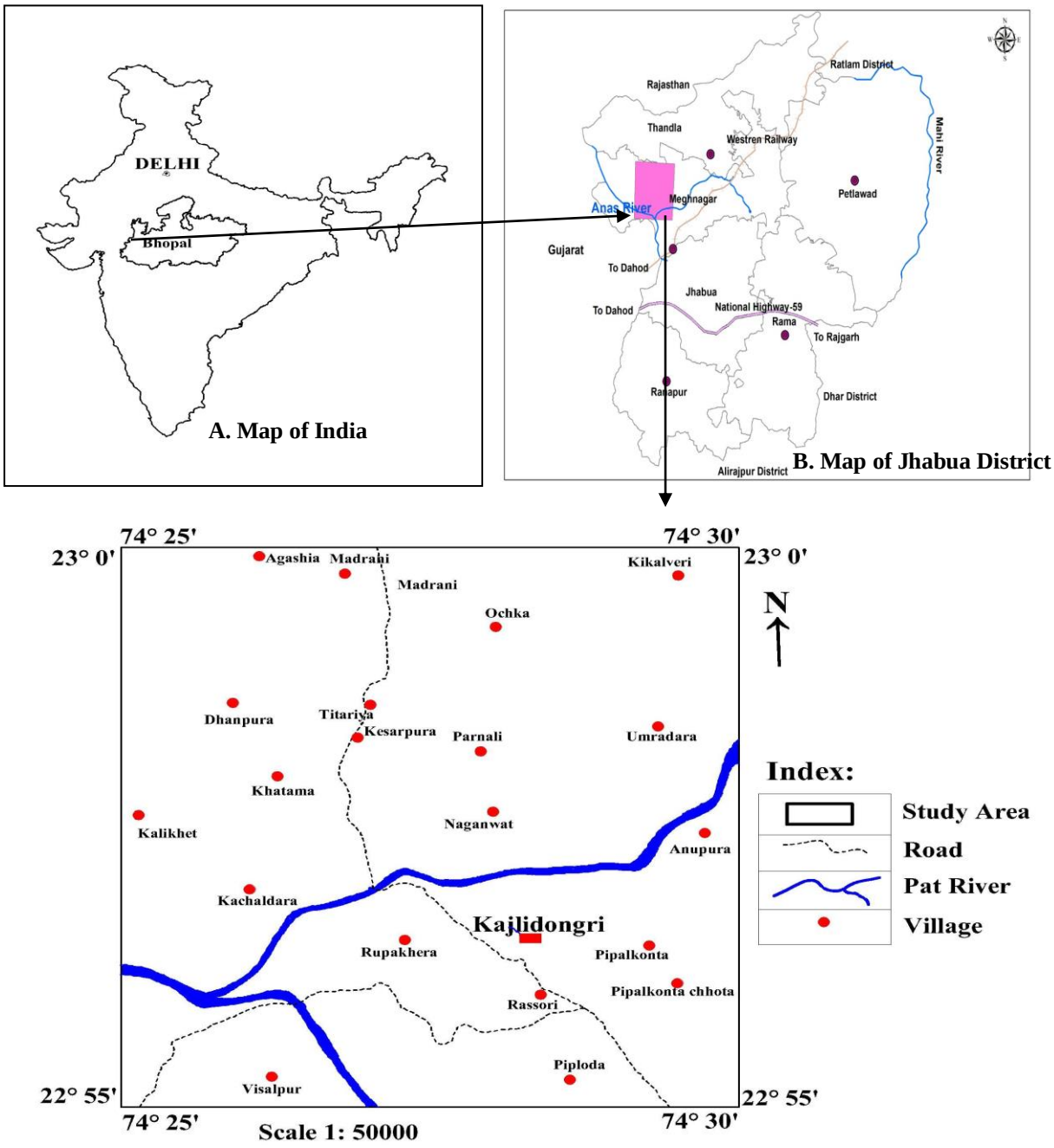

Figure 1: Showing location map of the Study Area, Jhabua District, Madhya Pradesh.

Geology of the study area:

The study area around Kajlidongri, Meghnagar region belongs to the Jhabua District of Madhya Pradesh, which is covered by Aravallis formations, Lametas & Bagh beds and lava flows of Deccan Traps.

Geologically, the study area is occupied by rocks such as the gneiss, schist, phyllite, quartzite, limestone, sandstone and basalt. The major portion of Kajlidongri village South- East part covered by the quartzite and Manganese bearing phyllite. The Khatama, Kachaldara, and Dhanpura villages of Meghnagar block, Jhabua District is covered by the Phosphate-bearing dolomitic limestone and limestone. The Geological evidence suggests that the Meghnagar block phosphorites, occurring within a calcareous facies with or without stromatolites, are a

product of deposition in a shallow-water marine environment (Khan et al. 2005).

METHODOLOGY

The study is based on the Primary and Secondary Data. The drainage pattern map is prepared on the basis the Survey of India Toposheet no. 46 J/5 on 1:50,000 Scale has been used for the morphometric analysis of the Pat River basin in around Kajlidongri area of Meghnagar Block. The Pat River drainage basin was divided into 6 sub-basins. The morphometric parameters here divided into three categories: linear, areal and relief aspects of the basin determined by adopting Horton's (1945) and the values of various parameters are displayed (Table 1, 2).

MORPHOMETRIC ANALYSIS

The examinations of linear, areal and relief parameters in respect of Pat River basin in around Kajlidongri area of Meghnagar Block (Figure 2, Table 2) have been described in the following text:

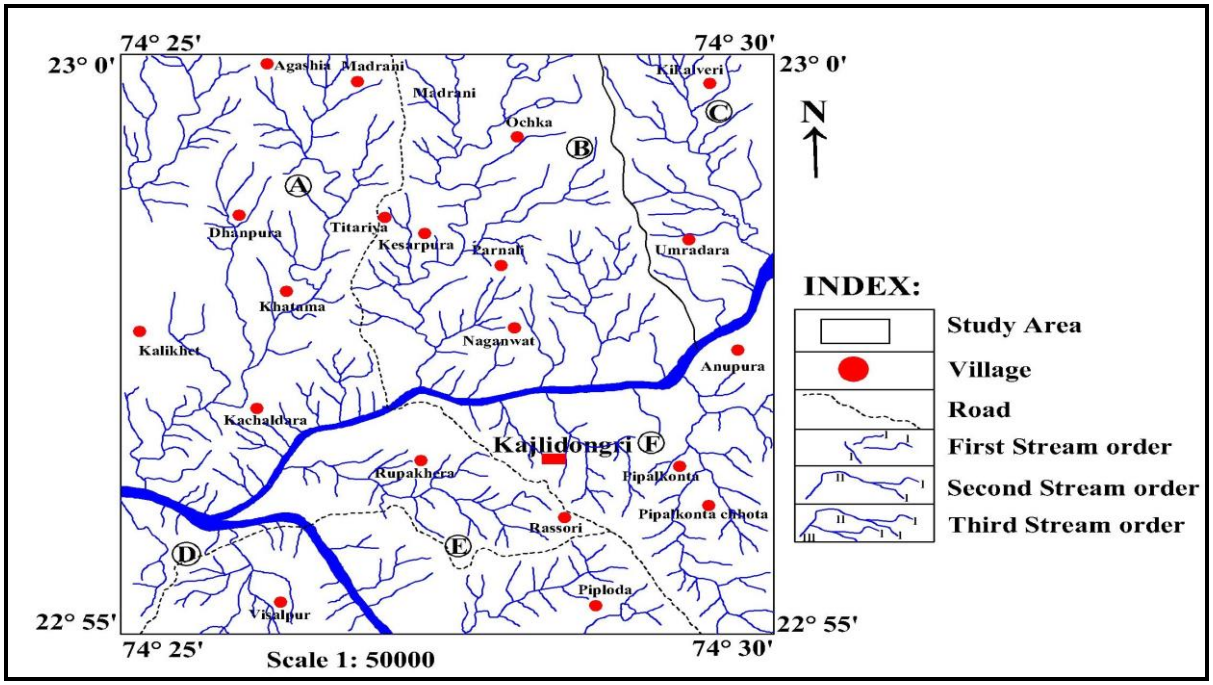

Figure 2: Drainage pattern of Pat River basin in around Kajlidongri study area.

Table 1: Showing details of the Pat River Drainage basins in around Kajlidongri area, Meghnagar block, Jhabua District, Madhya Pradesh.

Morphometric Variable (km/km²)	Drainage basins of Pat River (sub basin)					
	A	B	C	D	E	F
No. of Ist order streams	81	66	27	27	48	46
No. of IInd order streams	17	18	08	05	10	12
No. of IIIrd order streams	03	04	02	02	02	03
No. of IVth order streams	01	01	01	01	00	01
Total No. of streams	**102**	**89**	**38**	**35**	**60**	**62**
Length of Ist order stream	30.5	23	9.5	6.5	14.5	12
Length of IInd order stream	10.5	9.5	04	3.5	3.5	4.5
Length of IIIrd order stream	9.5	05	2.5	0.5	03	04
Length of IVth order stream	0.25	3.1	0.5	0.7	00	0.65
Total Length of stream (km)	**50.75**	**40.6**	**16.5**	**11.2**	**21.0**	**21.15**
Length of the sub basin	6.75	5.05	4.15	1.65	3.5	4.5
Width of the sub basin	3.45	4.0	2.1	3.0	3.35	3.75
Area of the sub basin (km²)	**23.29**	**20.2**	**8.71**	**4.95**	**11.72**	**16.87**

Perimeter of the sub basin (km)	17.0	15.5	10.5	8.5	13.5	16.5
Highest elevation within the sub basin (m.)	314	319	320	280	309	299
Lowest elevation within the sub basin (m.)	220	200	280	210	280	260
Area of circle with the same perimeter as of basin (km)	17.0	15.5	10.5	8.5	13.5	16.5

Table 2: Morphometric Parameters in respect of the Pat River basin in around Kajlidongri study area.

S. No.	Parameters (Notation)	Formula (unit)	Sub Basin A	Sub Basin B	Sub Basin C	Sub Basin D	Sub Basin E	Sub Basin F	Ave. value
1	Bifurcation Ratio (Rb)	I^{st} / II^{nd} order	4.76	3.66	3.37	5.4	4.8	2.87	4.14
		II^{nd} / III^{rd} order	5.66	4.5	4.0	2.5	5.0	4.0	4.27
		III^{rd}/IV^{th} order	3.0	4.0	2.0	2.0	00	3.0	2.33
2	Drainage Density (Dd)	Lu/A	2.179	2.009	1.894	2.262	1.792	1.254	1.898
3	Length of overland flow (Lo)	$1/D_{d\times}2$	0.229	0.249	0.264	0.221	0.279	0.398	0.273
4	Stream frequency (S_f)	Nu/A	4.379	4.406	4.363	7.070	5.119	3.675	4.835
5	Circularity Ratio (R_c)	4π A/P^2	1.012	1.056	0.992	0.860	0.807	0.778	0.917
6	Form factor (F_f)	A/Lb^2	0.511	0.792	0.506	1.818	0.957	0.833	0.903
7	Elongation Ratio (R_e)	$2\sqrt{(A/\pi)}$ /Lb	2.096	2.257	1.635	1.954	2.065	2.185	2.032
8	Lemniscate Ratio	$Lb^2/4A$	0.489	0.316	0.494	0.137	0.261	0.300	0.333
9	Basin Relief (H)	H_1- H_2	94	119	40	70	29	39	65.166
10	Relief Ratio (Rh)	H/ Lb	13.92	23.56	9.64	42.42	8.28	8.66	17.75
11	Ruggedness Number	H× Dd	204.83	239.07	75.76	158.34	51.97	48.91	129.81
12	Ground surface slope (Sg)	H× 2 Dd	409.65	478.14	151.52	316.68	103.94	97.81	259.62

A. Linear parameters:

Stream order:

The flow of surface water in a fixed route is called stream order. It was first introduced by Horton (1945), and later modified by Strahler (1952, 1957). A higher order channel segments is produced by the joining of two segments of a given lower order. The drainage basin of study area is characterised by the streams of first to forth order (Figure 2).

Bifurcation ratio:

The Horton's law of stream numbers (Horton, 1945), the bifurcation ratio is the ratio between numbers of segments of a given order to the number of segment of the next higher order (Nu+1). In present study area, the calculated average values of bifurcation ratio in the sub-basins show a variation from 2.33 to 4.27, which indicate that the existence of an elongated sub-basin.

Stream length:

The stream length has been computed based on the low proposed by Horton (1945) for all the six sub-basins of the study drainage basin (Figure 2). In the study basin area, the calculated values of Stream length in the sub basins of minimum 11.2 and maximum 50.75 km (Table 1). The maximum length of stream has been observed in sub basin "A" in the Madrani, Tetaria, Khatama, Agashia, Dhanpura, Kalikhet and Kachaldara.

B. Areal aspects:

Drainage Density:

Horton (1932) confined the drainage density (Dd) is an important indicator of the linear

scale of landform elements in stream-eroded topography. A low drainage density occurs in a region of high resistant or high permeable strata under dense vegetation, low relief and coarse drainage texture. High drainage density is due to the weak or impermeable subsurface material, sparse vegetation, mountainous relief and fine drainage texture (Strahler, 1964). The drainage density ranges from 1.254 (sub-basin F) to 2.262 (Sub-basin D). The average drainage density has been computed to be 1.898 (Table 2).

Stream Frequency:
Horton (1932) introduced stream frequency as the number of streams segment per unit area. It is obtained by dividing the total number of stream to the total drainage sub- basin area. The stream frequency of study area ranges from 3.675 (Sub-basin F) to 7.070 (Sub-basin D) with an average value of 4.835 (Table 2). It indicates that with increase in stream number, there is an increase in drainage density of the study region.

Form Factor:
The Form factor ratio (R_f), which is the dimensionless ratio of basin area to the square of basin length (Horton (1932). The Form factor varies from 0.506 (Sub-basin C) to 1.818 (Sub-basin D) and its average value of 0.903 (Table2).

Elongation Ratio:
Schumm (1956) projected that elongated ratio as the ratio of diameter of a circle of the same area in the basin to the maximum basin length. It is a very important indicator in the analysis of basin shape which helps to give an suggestion about the hydrological character of a drainage basin. The Elongation ratio of the study area ranges from 1.635 (Sub-basin C) to 2.257 (Sub-basin B) with an average value of 2.032 (Table 2).

Circularity Ratio:
The Circularity Ratio of study area ranges from 0.778 (Sub-basin F) to 1.056 (Sub-basin B) with an average value of 0.917 (Table 2).

Lemniscate ratio:
The Lemniscate ratio indicates a range from 0.137 (Sub-basin D) to 0.494 **(**Sub-basin C) for the study drainage basin and its average value of 0.333 (Table 2). The value of lemniscates ratio indicates elongated shape of the drainage basin.

Length of Overland Flow:
The length of overland flow varies from 0.221 (Sub-basin D) to 0.398 (Sub-basin F) with an average value of 0.273 (Table 2). In the study area, value of length of the overland flow is low indicating that the water covers a small distance on the surface before reaching into a definite channel.

C. Relief aspects:
Basin Relief:
Strahler (1952) considered that relief is the maximum vertical distance between the lowest and the highest points of a basin. The lowest elevation point of sub-basin is minimum 29 m (Sub-basin E), and the maximum height of sub-basin is 119 (Sub-basin B) m.

Relief Ratio:
The possibility of a close correlation between relief ratio and hydrologic characteristics of a basin suggested by Schumm (1956), he found that sediments loose per unit area is closely correlated with relief ratios. In the study area, relief ratio (Rh) ranges from 8.28 to 42.42 and its average value of 17.75 (Table 2).

Ruggedness Number:
Strahler's (1958) defined the ruggedness number is the product of the basin relief and the drainage density and usefully combines slope steepness with its length. In the present study drainage basin, the ruggedness number indicates a ranges from 48.91 (Sub-basin F) to 239.07 (Sub-basin B) with an average of 129.81 (Table 2).

Ground surface slope:
In the around Kajlidongri study area, ground surface slope point out a ranges from 97.81 (Sub-basin F) to 478.14 (Sub-basin B) with an average value of 259.62 (Table 2).

CONCLUSION

Morphometric parameters result such as stream order, bifurcation ratio (0 to 5.66), stream length (11.2 to 50.75 km), area of sub-basin (4.95 to 23.29), basin perimeter (8.5 to 17), length of basin (1.65 to 6.75), drainage density (1.254 to 2.262), stream frequency (3.675 to 7.070), form factor (0.506 to 1.818),

elongation ratio (1.635 to 2.257), circulatory ratio (0.778 to 1.056), lemniscate ratio (0.137 to 0.494), length of overland flow (0.221 to 0.398), basin relief 29 to 119, relief ratio (8.28 to 42.42), ruggedness number (48.91 to 239.07) and ground surface slope (97.81 to 478.14). The drainage pattern in the present study area is dendritic in nature. The present study area Visalpur Village high drainage density is observed over the hilly terrain with impermeable hard rock substratum and fine drainage texture. In the study area, coarse textured drainage or low drainage density may signify highly permeable rock materials. Low drainage density areas Anupura, Pipalkonta and Pipalkonta chhota Village are favourable for detection of groundwater potential sites and evolution of the Pat river drainage basin characteristics plays a significant role in the development of groundwater resources in around the Kajlidongri study area.

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