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Application of Morphometric Analysis in Ground water Exploration in Narwar – Palkhanda Sector of Ujjain District, Madhya Pradesh, India.

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Abstract : The paper incorporates the application of morphometric analysis in ground water extraction of the study area Narwar- Palkhanda located in Ujjain district of Madhya Pradesh, India. The area is characterized by the dominance of Deccan Traps (Cretaceous to Lower Eocene). Geomorphic landform features such as hills, mounds, valleys and soils are recognized. Morphometric analysis of study area drainage basin has been conducted on the basis of topographic map on 1:50,000 (Survey of India toposheet no. 46M/16). The determination of the morphometric parameters includes Areal, Linear and Basin Relief aspects such as Bifurcation ration (5.16), Drainage density (0.7), Length of over land flow (0.82), Stream frequency (0.34), circulatory ratio (0.32), Elongation ratio (0.35), Form factor (0.19), Lemniscate ratio (1.31), Basin relief (8), and Ruggedness number (6.64). The morphometric parameters of drainage basin indicate the existence of a dendritic drainage pattern. The morphometric analysis helps in the identification of ground water potential sites in the Narwar-Palkhanda sector of Ujjain area. The conventional technique of morphometric analysis has been adopted in this paper to visualize the characteristics of Narwar-Palkhanda drainage basin and their applications in delineation of ground water potential sites to resolve the problem of regular water supply.

Key words: Application, Morphometric analysis, Ground water, Narwar-Palkhanda, Ujjain, Madhya Pradesh, India

Introduction

The area of investigation is located in Narwar-Palkhanda of Ujjain district, Madhya Pradesh at a distance of 20 km from Ujjain town. The study area forms the part of the Malwa plateau exhibiting terraced or strap like structures with irregular isolated hills and represents uneven to undulating topography with a gentle slope towards North. Average height of the area is from 532m to 500m A.M.S.L. The minimum elevation is 500 m A.M.S.L and the maximum elevation of the area is noted as 532 m A.M.S.L. Deccan Trap group covers an extensive area consists of sequence of 02 basaltic lava flows with cumulative thickness of 32 m. The study area belongs to Middle division of the Deccan Trap. The lowlying plains are restricted to the major river valleys in the northern parts, and the rise in elevation is very gradual. The first geological account has been given by Blanford (1869) and followed by several workers. Recently, Barbele (2012) carried out hydrogeological studies in Narwar – Palkhanda area.

Location of the Study area

The present study area constitutes a part of Kshipra River Basin in the vicinity of South -Western Sector of Ujjain in Madhya Pradesh, which is one of the holy religious cities of ancient India. The study are (Figure. 1) is confined to latitude - 23°02' and 23°07' N and longitudes 75°53' and 76°00 E (Survey of India Toposheet No. 46M/16). General climate is pleasant and healthy.

Geomorphology of the study area:

Geomorphology has been defined as “The systematic description and analysis of landscapes and the processes that change them” (Bloom 1979). Geomorphological features of study area are due to the result of number of lava flows, their lithological variations drainage patterns and relief features. Thicknesses of soil cover nature of weathering and climatic conditions. The depositional and erosional landforms are developed in the area of present investigation. The differential hardness of rock masses is evidence of their resistance to weathering.

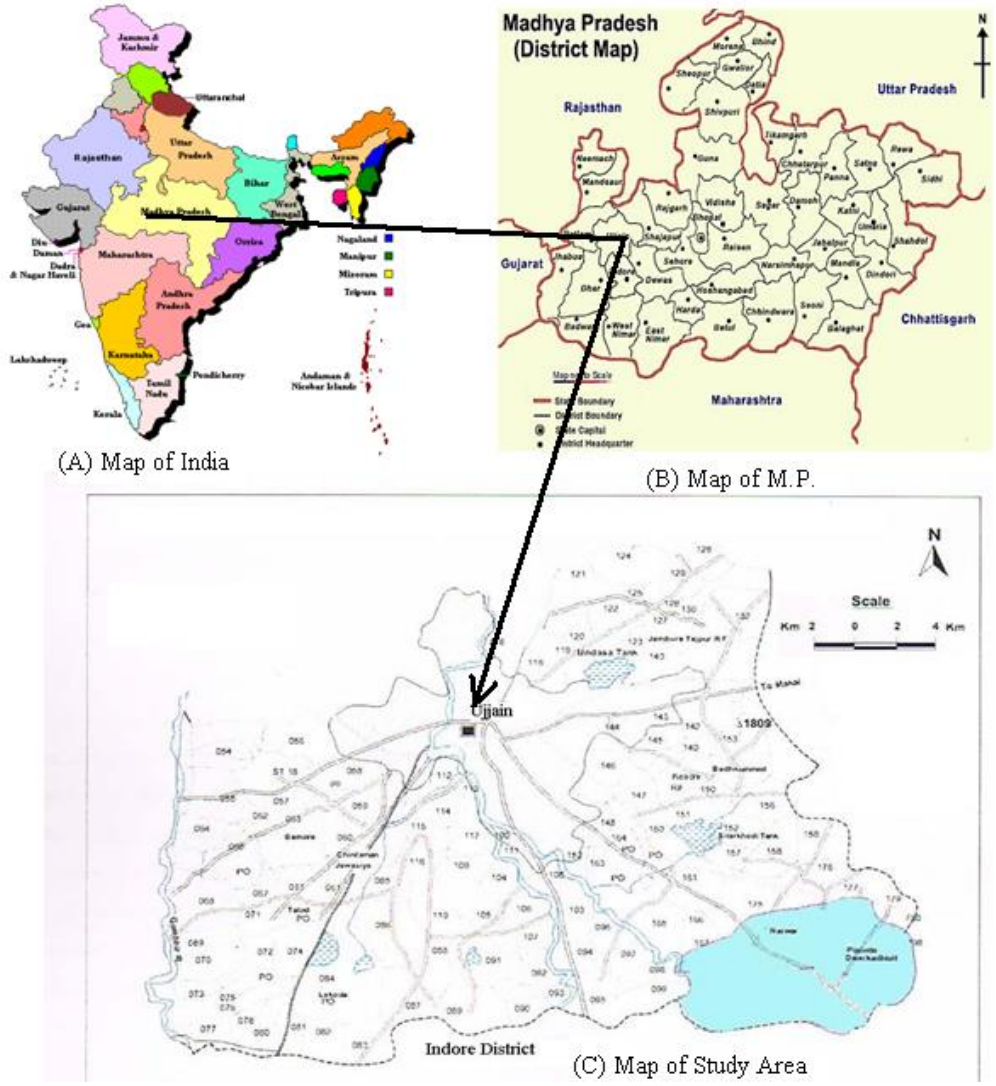

Figure 1. Showing location map of the Narwar-Palkhanda study area Ujjain district (M.P.).

Geomorphic Features:

The important landform features witnessed in the Ujjain area include hills, mounds, valleys and soils. The characteristics are elaborated herein.

Hills and Mounds:

The study are mainly consists of plain and hillocks. Structurally the area is not affected by any major structural disturbance. The major hillocks or mounds are founds around Madhopura, Undasa Madhopura, Gamri villages.

Valleys:

Narwar and Palkhanda nalas mainly drain in the area. The Narwar nala and Palkhanda nala are joining river Kshipras in the south west.

Soils:

The soils are formed due to the weathering effects on the Basaltic rock, it is mainly covered with black cotton soil, which is having high clay content, low permeability, high moisture content, high plasticity and water retaining capacity. The alluvial soil is developed along the bank of Kshipra River having light yellow to gray.

Morphometric Analysis:

Morphometric analysis has been defined as the measurement and mathematical analysis of the configuration of the earth surface and the slope and dimension of its land form (Clarke 1966). In fact, Morphometric incorporates the quantitative study of an area, volume, slope, profiles of the land, and drainage basin characteristics of the area concerned. Morphometric analysis of the drainage basin in the study area, district Ujjain M. P, has been carried out on the basis of topographical map on 1: 50,000 scale (Survey of India toposheet no. 46 M/16).The geomorphic observation of quantitative and qualitative analysis of the study area verified by undertaking field

checks. The drainage map of the study area has been prepared (Figure 2).The determination of morphometeric parameters have been performed with the help of a Rota meter. The methods suggested by Horton (1945), Strahler (1952), Schumm (1956) and others.

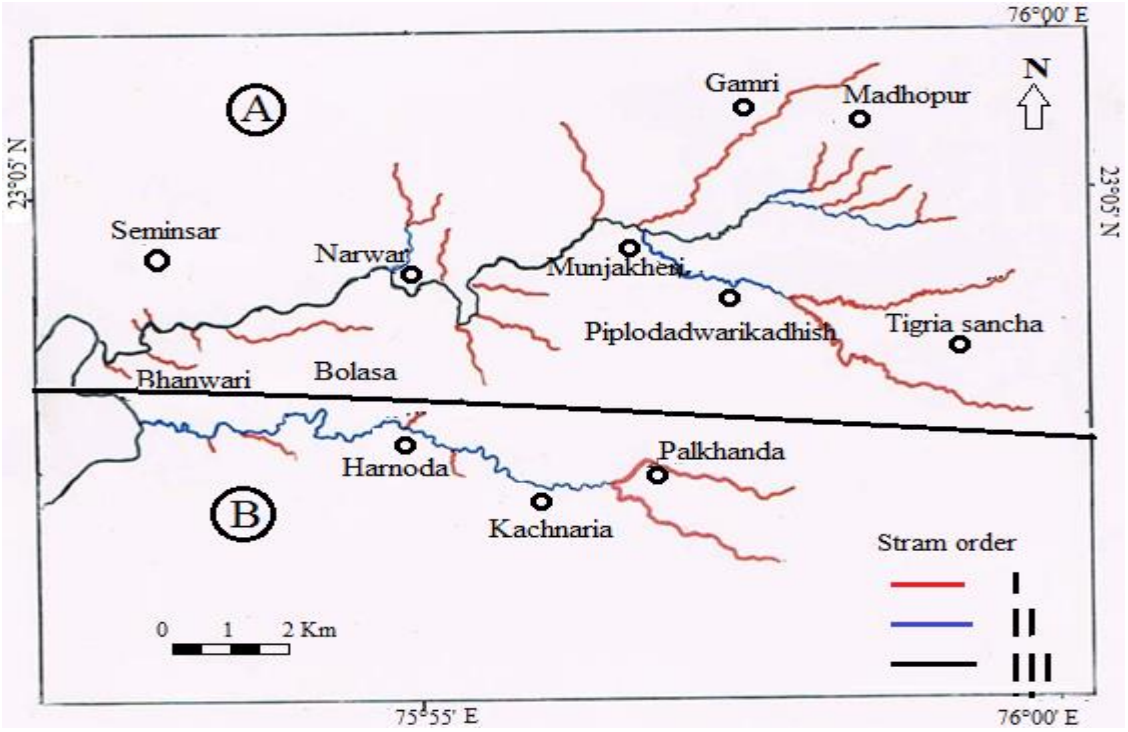

Figure 2 showing drainage map of the Narwar-Palkhanda study area Ujjain district (M.P.)

Table 1: Showing details of the drainage basin in study area Narwar, Palkhanda Ujjain district M.P.

S.No.	Parameters	Sub Basin	
		A	B
1	No. of 1st order streams	22	06
2	No. of IInd order streams	04	01
3	No. of IIIrd order streams	01	0
4	**Total no. of stream**	**27**	**07**
5	Length of Ist order stream	28	9
6	Length of IInd order stream	7	10
7	Length of IIIrd order stream	15	0
8	**Total length of streams**	**50**	**19**
9	Basin parameter	43.2	41.5
10	Length of basin	15.7	15.7
11	Width of basin	6.6	5.4
12	Area of basin	51.81	42.39
13	Highest point	532	523
14	Lowest point	520	519

Stream order:

The system for stream ordering suggested by Horton (1945) and modified by Strahler (1952) has been followed. There are three orders of streams (Table .1, Figure 2).

Stream number:

The counting of stream channel in its order is called as stream number. The number of stream segments decreases with the increase of order. The highest number of First order streams has been noted in sub-basin A and third order is observed in sub-basin A (Table .1, Figure 2).

Stream length:

Stream Length of sub-basin A and B has been measured with the aid of Rota meter. The Length of stream is indicative of the controlling area of the basin of that order. Maximum length of streams is recorded in sub-basin A.(Table .1, Figure 2).

Bifurcation ratio:

The term bifurcation ratio is used to express the ratio of the number of streams of any given order to the number of streams in the next higher order.

Rb = Nu / Nu + 1

Where,

Rb = Bifurcation

Nu = number of streams of given order

Nu + 1 = number of streams of the next higher order

Table 2 : Showing values of Bifurcation ratio of study area drainage basin, Ujjain district, Madhya Pradesh:

Sub Basin	Stream Order	Stream No.	Rb	Average
A	1	22	5.5	
	2	4	04	
	3	1	-	5.16
B	1	6	06	
	2	1	-	
	3	0	-	

Drainage Density:

Drainage density denotes the total stream lengths per unit area. Horton (1945) defined drainage density as a ratio of total length all stream segments in a given drainage basin to the total area of the Basin, It is derived as follows:

Dd = Lk / Ak

Where,

Dd = Drainage density

Lk = total lengths of all stream segments of a basin

Ak = total area of the basin

Table 3: Showing Drainage density of study area drainage basin of Ujjain district, Madhya Pradesh

Sub Basin	Area of Basin	Total Length of streams	Dd	Ratio
A	51.81	50	0.96	0.7
B	42.39	19	0.44	

Length of over land flow:

Horton (1945) and Schumm (1956) considered the length of over land flow as horizontal length of flow path from the divided to the stream in a first order Basin and is a measure of stream spacing and degree of dissection and is approximately one half, the reciprocal of drainage density. Length of over land flow is expressed as:

Lo = 1 / 2 Dd

Where,

Lo = length of over land flow

Dd = Drainage density

Table 4: Showing Length of overland flow of study area drainage Basin of Ujjain district Madhya Pradesh:

Basin	Drainage Density	Lo	Average
A	0.96	0.52	0.82
B	0.44	1.13	

Stream frequency (SF) :

Stream frequency is expressed as the ratio between the total number of streams and area of the basin. It is determined as per the following formula:

Sf = Nu / A

Where,

Sf = stream frequency

Nu = sum of all number of stream Basin

A = total area of drainage in km^2

Table 5 : Showing stream frequency of study area drainage basin of Ujjain district, Madhya Pradesh.

Sub-Basin	Area of Basin (km^2)	No. of stream	SF.	Average
A	51.81	27	0.52	0.34
B	42.39	7	0.16	

Circulatory ratio (Rc) :

Circulatory ratio is the ratio between the basin and the area of the circle having the same perimeter as that of the basin. It is calculated by formula:

$Rc = 4nA/P^2$

Where,

A = Area of Basin,

P^2 = Area of circle with some perimeter as of the Basin

Table 6 : Showing Circulatory ratio of study area drainage basin of Ujjain district Madhya Pradesh:

Sub-Basin	Area of Basin	Perimeter Basin	Rc	Average
A	51.81	43.2	0.34	0.32
B	42.39	41.5	0.30	

Elongation Ratio (Re):

Elongation ratio is the ratio between the diameter of the circle having the same area and the maximum length of the basin. It is computed as:

$$R_e = 2 / L\sqrt{A / \pi}$$

Where,

A = Area of Basin

L = Length of Basin

Table 7: Showing Elongation Ratio of study area drainage basin of Ujjain district Madhya Pradesh.

Sub-Basin	Area of Basin	Basin Length f	Re	Average
A	51.81	15.7	0.37	0.35
B	42.39	15.7	0.33	

Form Factor: (F)

The form factor is expressed as the ratio between basin area and square root of the basin length.

$F = A/ L^2$

Where,

A = Area of Basin

B = Basin Length

F = Form Factor

Table 8: Showing Form factor of study area drainage Basin of Ujjain district Madhya Pradesh:

Sub-Basin	Area of Basin	Basin Length	F	Average
A	51.81	15.7	0.21	0.19
B	42.39	15.7	0.17	

Lemniscates ratio:

Lemniscates ratio based upon the expression at the basin with Lemniscates curve (ratio of basin area and basin length) Lemniscates ratio determines the shape of the drainage basin. It is denoted by the symbol 'K'. It is generally expressed by the following formula.

$K = L^2/ 4A$

Where,

L = Basin Length

A = Basin area

Table 9: Showing Lemniscates ratio of study area drainage Basin of Ujjain district Madhya Pradesh:

Sub-Basin	Length of Basin	Area of Basin	K	Average
A	15.7	51.81	1.18	1.31
B	15.7	42.39	1.44	

Basin Relief:

Basin aspect of the sub-basins play an important role in drainage development, surface sub surface water flow, permeability, land forms, development and associated features of the terrain. Basin relief is the difference between the highest and lowest point in the basin area. (Strahler, 1952).

H = Highest point of basin – Lowest point of basin

Table 10: Showing Basin Relief of study area drainage basin of Ujjain district, Madhya Pradesh.

Basin	Highest point of basin	Lowest point of basin	H	Average
A	532	520	12	8
B	523	519	4	

Ruggedness number (nd)

Strahler (1958), defined it as the product of maximum relief and drainage density

nd = H X Dd

Where,

nd = Ruggedness number

H = Maximum basin Relief

Dd = Drainage density.

Table 11 : Showing ruggedness number of study area drainage basin of Ujjain district, Madhya Pradesh:

Sub-Basin	Maximum Basin Relief	Dd	nd	Average
A	12	.96	11.52	6.64
B	4	.44	1.76	

Interpretation of Morphometric Analysis:

The results of morphometric analysis of the drainage basin of Narwar – Palkhanda area of Ujjain district, Madhya Pradesh, are discussed in the following text:

Bifurcation ratio:

The Bifurcation ratio value of the study area sub-basin A = 9.5 and sub-basin B = 6.

The lower Bifurcation ratio (Rb) values in the sub-basin B are the characteristic of less structural disturbances and hence the drainage pattern has not been distorted (Strahler 1964) where as higher Bifurcation ratio in the sub-basin A indicate high structural complexity and low permeability of the terrain.

Drainage Density:

The Drainage density of the sub-basin A is (0.96) and sub-basin B (0.44). Low Drainage density exists having high permeable sub soil material under dense vegetation cover and low relief, in contrast high drainage density indicate the presence of impermeable sub surface material and high relief.

Length of over land flow:

The commuted values of length of over land flow vary from (0.52 to 1.13) with an average of (0.82) and it indicates that the water covers a very short distance before immerging into the drainage channel.

Stream frequency:

Stream frequency of the sub-basin B (0.16) and sub-basin A (0.52). Sub-basin B exists in low value (0.16) of stream frequency shows high permeable lithology and low relief of the basin and sub-basin. A exists in high value of (0.52) stream frequency indicates a high relief, impermeable sub-surface material and low infiltration capacity of basin.

Circulatory ratio:

Circulatory ratio values of sub-basin B (0.30) and sub-Basin A (0.34). Circulatory ratio values approaching first indicate that the basin shape are like circular as a result it scope for uniform infiltration, which further subjected to lithology slope and overland. The sub-basin B exists of minimum value (0.30), sub-basin A exists maximum value (0.34), both value are less than

unite value so it indicate that the basin shape are less circular in shape.

Elongation ratio:

Elongation Ratio values of sub-basin B (0.33) and sub-basin A (0.37). The sub-basin B exists in low value of (0.33), sub-basin A exists in high value of (0.37). The low Elongation ratio value indicates low infiltration and high run off and the higher values indicate high infiltration and low runoff.

Form Factor:

Form factor of the sub-basin B (0.17) and sub-basin A (0.21). The sub-basin B having low form factor have less side flow for shorter duration. Sub-basin A in high form factor shows having high side flow for large duration and low main flow for shorter duration.

Lemniscates ratio:

The value of Lemniscates ratio calculated for the study drainage basin sub-basin A (1.18) and sub-basin B (1.44).Drainage basin range from minimum value 0.59, sub-basin A and maximum value 0.72 sub-basin B which reviles that the drainage is more or less elongated in shape.

Basin relief:

The values of basin relief have been calculated for all sub-basins indicating a range for 4 to 12 meter with an average of 5 meter. The high basin relief value indicates the high gravity of water flow, low infiltration and high run off conditions of sub basins.

Ruggedness number (nd) :

Ruggedness number indicates the structural complexity of a terrain in association with relief and drainage density the basin having high. Ruggedness number values are susceptible to soil erosion and sedimentation load (Strahler 1958).The sub-basin A having a maximum Ruggedness no. (11.52) value and sub-basin B having a low Ruggedness value (1.76) and the average Ruggedness no. value is (6.64).

Conclusion:

Morphometric analysis deals with the features of study area which is exhibiting the predominance of undulating topography. This study provides a brief description of different geomorphic features such as land forms, valleys and soils. Morphometric analysis of study area drainage basin has been conducted on the basis of topographic map on 1:50,000. The determination of the morphometric parameters includes Bifurcation ration (5.16), Drainage density (0.7), Length of over land flow (.82), Stream frequency (0.34), circulatory ratio (0.32), Elongation ratio (0.35), Form factor (0.19), Lemniscate ratio (1.34), Basin relief (8), and Ruggedness number (6.64). The morphometric parameters indicate the existence of a dendritic drainage pattern. Geomorphic evidences are helpful in demarcation of the ground water locations in the vicinity of the Ujjain study area.

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