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Morphometric Analysis of Kelo Basin for Environmental Impact Assessment

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Abstract:- The Chhattisgarh region is characterized by non-perennial streams, which actually are rain-fed rivers. They carry water only during and immediately after rain. During the dry season either they may cease to flow entirely, or there is hardly any water in most of the drainage channels. Clearly, watersheds with a higher proportion of area drained by non-perennial streams will tend to have lower soil moisture retention and water harvesting capability than those areas where perennial streams pre-dominate. Ceteris paribus, areas with proportionately more perennial streams should be fewer droughts vulnerable. Catchment areas can be described by their stream channel patterns, as viewed from maps or from the air. Each stream has its characteristic channel, based on the topographical obstacles encountered, as it seeks the `path of least resistance' in its journey towards the sea. Stream patterns may develop randomly on uniform soils, or in response to weaknesses in the underlying geology .

Keywords – Kelo Basin, Environment.

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1. INTRODUCTION

In Chhattisgarh most of the drainage pattern has been structurally guided, and arises from the presence of hard underlying rocks, as well as pronounced zones of faults and fractures. This means that the channel form is controlled by geology, the flow is confined within rock outcrops, and the channel morphology determined by the relative strength and weakness of the bed material. Dendritic pattern is found in areas of relatively uniform geological structure in the river valleys. Trellis pattern usually develops on alternating bands of hard and soft strata. Rectangular pattern is common in areas with right-angled faults and/or joints, such as in granitic bedrock areas. Stream Orders and Stream-Ordering Methods Stream ordering is a widely applied method for classifying streams. Stream order is an indicator of the degree of branching, or bifurcation, within a basin. Horton has classified stream order by assigning order 1 to small, unbranched, finger-tip tributaries, order 2 to those streams which have branches of the first order only, order 3 to streams with branches of second and lower orders, etc. Thus the order of the main stream indicates the extent of branching in the basin. This classification is the inverse of the European system, in which the main stream is always classified as first order and the extreme tributaries as the highest order. Its use in classification is based on the premise that the order number has some relationship to the size of the contributing area, to channel dimensions and to stream discharge (Strahler 1974). Strahler's method has been widely accepted as least subjective and is commonly used by stream biologists. In this system all the small, exterior streams are designated as first order, `those which carry wet weather streams and are normally dry' (Strahler, 1952, p. 1120). A second-order stream is formed by the junction of any two first-order streams; third-order by the junction of any two second-order streams. Here, only one stream segment has the highest order number, rather than the whole parent stream.

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms[2]. Morphometric studies in the field of hydrology were first initiated by harton & strehlar. The morphometric analysis of the drainage basin and channel network play an important role in understanding the geo-hydrological behavior of drainage basin and expresses the prevailing climate, geology, geomorphology, structural antecedents of the catchment. The relationship among various drainage parameters and the aforesaid factors are well recognized by many workers [5-9]. The drainage basin analysis is important in any hydrological investigation as assessment of groundwater potential, groundwater management, pedology and environmental assessment. Hydrologists and geomorphologists have recognized that certain relations are almost important between runoff characteristics, and geographic and geomorphic characteristics of drainage basin systems. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as size, shape, slope of drainage area, drainage density, size and length of the contributories etc. [10]. Geology, relief and climate are the primary determinants of running water systems functioning at the basin scale [11]. Geographical Information System (GIS) techniques are now-a-days in use for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as it provide a flexible environment and an important tool for the manipulation and analysis of spatial information.

The objective of the present study was to analyze the linear, areal and relief morphometric attributes of Kelo drainage basin .This study is attempted to use the morphometric technique vis-a-vis GIS to give an insight of the different geo-hydrological characteristics of the drainage basin to help in the identification of ground water potential zones and overall management of the basin with focus on groundwater.

2. LINEAR MORPHOMETRIC PARAMETERS

Linear aspects of the basins are closely linked with the channel patterns of the drainage network wherein the topological characteristics of the stream segments in terms of open links of the network system are analyzed. The morphometric investigation of the linear parameters of the basins includes Order of stream U (number) bifurcation ration Rb(number),basin length L(Km),Dia. of circle with basin area D (Km), catchment area Au (Km^2),elongation ration D/L Re, Area of circle having same perimeter of basin Ac (Km^2), form factor (Au/L2) Rf, Circulatory ratio (Aμ/Ac) Rc, Drainage density d.

Basin Characteristic of Kelo River: The measurement of landform, morphometry, is important factor in evaluating hydraulic parameters of Kelo basin. The basin characteristics of Kelo basin where proposed opencast /underground mine will be located. No part of the drainage will be diverted. Drainage analysis of Kelo River has been evaluated and compared with model proto basin study **(Figure-1)**. Model for Indian Coal Field had developed rainfall runoff recharge model on three different proto basins for opencast mining areas, underground mining areas and non-mining areas. Before using the model for present mine, it is imperative here to compare the basin characteristic of these three proto basins with Kelo basin where the study area is located. Morphometric analysis of Kelo basin along with data of Model study is placed in **Table-1** and **Table-2.**

Table 1. Morphometric Analysis Of Kelo Basin

Order of Stream (U)	NU	Log NU
1	594	2.77
2	152	2.18
3	37	1.57
4	12	1.08
5	0	0.0

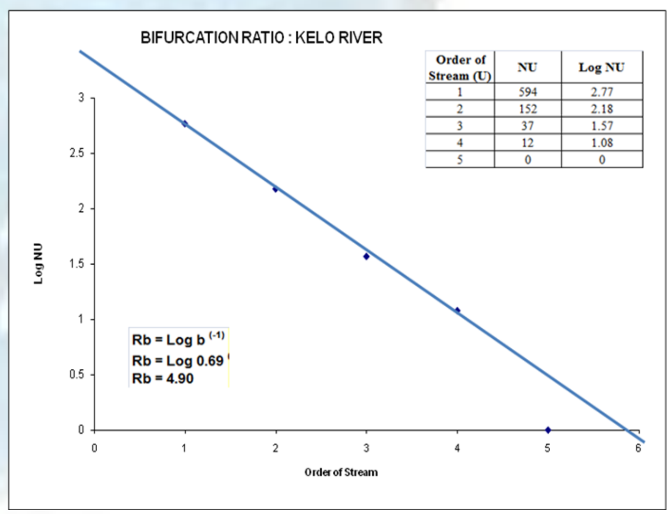

Fig 1. Bifurcation Ratio: Kelo River

Table 2. Basin Characteristics

S.N.		Parameter	Symbol	Unit	Model Proto basin			Kelo basin at study area
					O/C	U/G	Non mining	
A		LINEAR						
	1	Stream Order	U	Number	5	5	5	5
	2	Bifercation Ratio	Rb	Number	4.73	4.16	3.67	4.90
	3	Basin Length	L	Km	13	10	16	28
	4	Dia of Circle with Basin area	D	Km	10.7	8.7	9.3	17.98
B		AREAL						
	1	Catchment area	Au	Km²	90	60	68	254
	2	Elongation ratio (D/L)	Re		0.82	0.87	0.58	0.64
	3	Area of circle having same perimeter of basin	Ac	Km²	121	53	127	535
	4	Form factor (Au/L²)	Rf		0.53	0.6	0.26	0.32
	5	Circulatory ratio (Au/ Ac)	Rc		0.74	0.88	0.53	0.47
	6	Drainage Density	d		1.38	1.36	1.37	1.56
	7	Stream frequency			1.37	1.28	1.3	1.69
C		RELIEF						
	1	Channel slope			0.004	0.005	0.004	0.0107
	2	Basin maximum elevation MSL		m	240	235	240	560
	3	Basin minimum elevation MSL		m	186	182	176	260
	4	Elevation fall		M	54	53	64	300

The bifurcation ratio of proto basins of Model are in the range of 3.67 to 4.73. Whereas the bifurcation ratio of Kelo basin is 4.90. Horton observed, "Bifurcation ratio characteristically ranges from 3 to 5 for watershed in which geological structure does not distort the drainage pattern". From this it can be concluded that above value of bifurcation ratio indicate that geological structure has not affected the drainage pattern of the basin under consideration i.e., both proto basins and Kelo river. From the study of the other basin characteristics it is observed that the basin under study is comparable with protobasin of Model. The Model developed for Indian Coal Field. In UNDP study can be used to establish relationship between rainfall and runoff coupled with rainfall and recharge for the Kelo river basin where Gare Pelema-III coal block is located.

Drainage Impact Assessment: Considering model, developed for Indian Coal Field, applicable to the study area, a relationship on unit area basis have been attempted to analyze the drainage impact assessment in pre and Post-Mining condition.

Rainfall – Surface flow Relations: Based on Model study, the analysis of surface flow in Coal Block project depict the anticipated hydrological consequences of mining operation during pre-mining and Post-Mining conditions. The study of **Table-3** & **Figure 2** states that there is reduction in surface flow in opencast mine area.

Table 3. Rainfall – Surface Flow Relations (Annual) (Unit Area Basis)

Phase/Condition	Average annual rainfall in m	Surface runoff Area m² x 10⁶ (re Zone)	Model surface flow coefficient	Surface flow MCM
Pre mining	1.639	6.39	0.25	2.62
Post Opencast mining	1.639	4.42	0.15	1.09
Post Underground mining	1.639	1.97	0.23	0.74

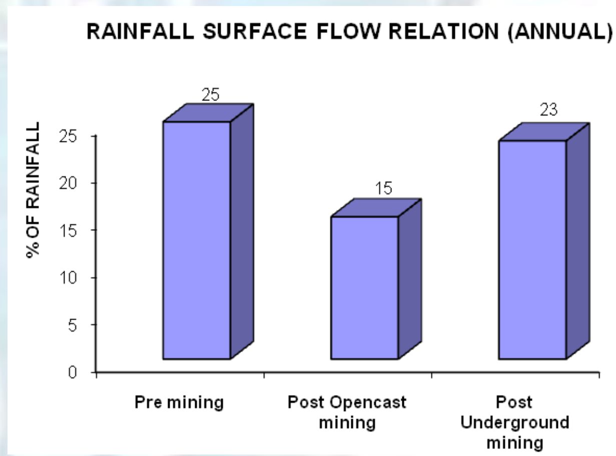

Fig 2. Rainfall Surface Flow Relation (Annual)

It can be stated that due to mining there will be reduction in flow in the drainage to the tune of 0.79 MCM. This may be due to increase in induced infiltration in the area. The induced infiltration will contribute to drainage as groundwater runoff for the longer period of utilization.

Apart from the surface flow the Kelo basin have ground water runoff. During mining it will be increased by addition of mine inflow into systems.

Rainfall – Infiltration Relation: Study done for Indian Coal Field has established a model to calculate induced infiltration from normal rainfall over the land in different condition. The same is applied in the study area and the output is placed in **Table-4**.

Table 4. Rainfall – Infiltration Relation (Annual) (Unit Area Basis)

Phase/ Condition	Average annual rainfall in m	Area $m^2 \times 10^6$	Model infiltration coefficient	Annual induced infiltration due to rainfall in MCM	Remarks Increase in infiltration due to mining MCM
Pre mining	1.639	6.39	0.10	1.05	(1.52 + 0.45) – 1.05 = 0.92
Post Opencast Mining	1.639	4.42	0.21	1.52	
Post Underground Mining	1.639	1.97	0.14	0.45	

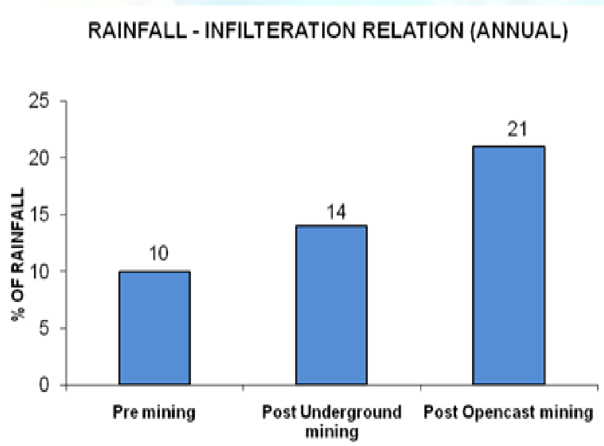

Fig 3. Rainfall – Infilteration Relation (Annual)

The induced infiltration in Post-Mining period will increase to the tune of 0.92 MCM due to propagation of cracks and shattering of formation (**Figure 3)**.

3. CONCLUSION

Impact assessment reveals that in course mining area there will be induced infiltration due to heavy withdrawal of water from system and creation of high infiltration zone. The blasting in operation of mine accelerates induced infiltration which will limit the radius of influence in opencast mine during mining and Post-Mining period. There will be reduction in surface flow due to high infiltration zone created in mining operation. At the end of mining activities, water contribution of the Kelo river will balance the impact. Thus, the impact on drainage will be temporary and will be restored after mining operations.

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