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Hydro - geomorphological investigation of Kharun Catchment in Chhattisgarh

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■ **ABSTRACT :** Knowledge of behavior of basin is prerequisite for taking rainfall – runoff modeling studies. This study aims to understand the hydrological and geomorphological behaviour of the catchment of river Kharun. Geomorphological parameters of Kharun catchment were generated by using the combination of the survey of India toposheets No. 64-G and 64-H on 1:250,000 scale. The river network has been ordered using Strahler's ordering scheme and it was found to be as fifth order basin having bifurcation ratio, stream length ratio and stream area ratio as 3.87, 1.1 and 4.56, respectively. 20 years of rainfall – runoff records of Kharun basin was analysed. The catchment behaviour to infiltration and other losses is not constant. The linear best fit of runoff - rainfall ratio values for past 20 years showed a declining trend. The average runoff – rainfall ratio in the reported years (1990 to 2009) was found to be 0.3444.

■ **KEY WORDS :** Hydrological, Geomorphological, Kharun, Catchment, Rainfall, Runoff

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Most of the rivulets and tributaries in Chhattisgarh gets dried up by mid winter season. Consequently rural as well as urban areas faces severe water crisis during summer season. On the other hand demand of water for domestic, agricultural, industrial and power generation purposes is increasing day by day. Like in country, Chhattisgarh also receives major part of rainfall only within three monsoon months. The hydrological data monitoring network is not adequate for sustainable water resources development and management and there is need to explore the hydrological behavior of the catchment.

The geomorphological parameters which are important from the hydrologic studies point of view include the linear, areal and relief aspects of the watershed. Geomorphological parameters also play an important role in development of Geomorphological Instantaneous Unit Hydrograph. Horton (1945) originated the quantitative study of channel networks. He developed a system for ordering stream networks and derived laws relating the number, length and catchment area associated with streams of different orders. Under the impetus supplied by Horton, the description of drainage basins and channel networks was transformed from a purely qualitative and deductive study to a rigorous quantitative science capable of providing hydrologists with numerical data of practical value. Strahler (1957) slightly modified Horton's (1945) classification scheme. He explained geometrical and mechanical aspects of drainage basins on the basis of dimensional analysis. This paper aims at exploring the hydrological and geomorphological behavior of the catchment of river Kharun.

■ METHODOLOGY

The State of Chhattisgarh has geographical area of about 135,100 km^2 and is divided into five river basins *viz*., Mahanadi, Godavari, Ganga, Brahmani and Narmada. The area selected for study is the catchment of river Kharun. It is situated inside the Shivnath basin of well known Mahanadi river basin in Chhattisgarh. Kharun is a non-perennial river, originating from village Petechua of Balod district and after flowing about 164 km joins Shivnath river near Somnath in the north. The total catchment area of Kharun river is 4118 km^2 and is located between the geographical co-ordinates 20^0 33' 30" - 21^0 33' 38" N latitude and 81^0 17' 51" E - 81^0 55' 25" E longitude. However, the catchment upstream to the gauging and discharge measurement site of Central Water Commission on the river Kharun at "Pathardih", comprises an area of 2511 km^2 The Kharun catchment is shown in Fig. A along with the Thiessen polygons, drawn to get average

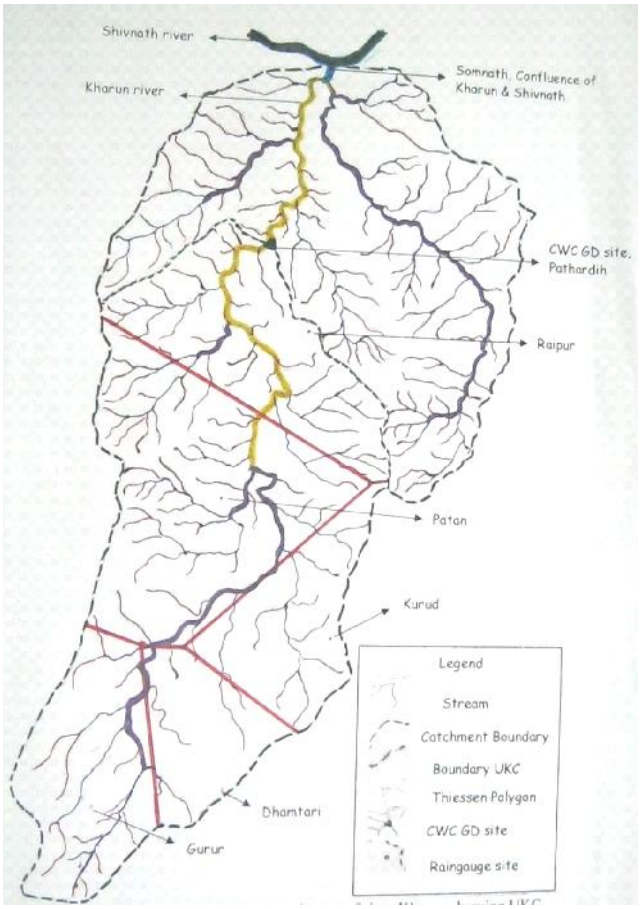

Fig. A : Drainage network map of Kharun catchment with Thiessen polygon

precipitation in the study area. The gauging site "Pathardih" is located at $21^0\ 20'\ 28''$ N latitude and $81^0\ 35'\ 48''$ E longitude.

Climate of Chhattisgarh state is dry sub-humid type. It has three agro-climatic zones *viz*., Northern Hills Zone, Chhattisgarh Plains Zone and Bastar Plateau Zone. The study area lies in the Chhattisgarh plains. Frequency of moderate to severe drought is around 6 to 7 years and the recurrence of drought on a lower scale is in every 3 to 4 years (Das *et al*., 2009). The study area is underlain by diverse rock types having their particular hydrological characteristics, which control groundwater occurrence, movement and availability. The Archaean crystallines comprising granites, gneisses form the major litho units of the area. They form discontinuous, unconfined and semi-confined aquifers.

Four major types of soil are found in the study area namely, Bhata (Entisols - Sandy loam), Matasi (Inceptisols - Sandy clay loam), Dorsa (Alfisols - Loam) and Kanhar (Vertisols - clay). Kanhar is seen in the lowest portion of the topo-sequence and is black in colour and ideal for the cultivation of crops. Dorsa and Matasi (midland soil) are suited for the growth of rice and Bhata (upland) for Kodo, Kulthi, Maize and Kutki. The area around Kharun river is very fertile.

Gauging of the river Kharun at Pathardih site was started in September 1989 by the Central Water Commission (CWC), Ministry of Water Resources, Govt. of India, New Delhi. The daily gauge – discharge (GD) data for the years from 1990 to 2009 were obtained from the O/o Chief Engineer, Central Water Commission, Bhubaneshwar, Orissa. Rainfall data of the rain gauge stations in and around the study area were collected from Department of Agro-meteorology, IGKV, Raipur and State Data Centre, Department of Water Resources, Govt. of Chhattisgarh. Locations of the daily rainfall measuring stations, installed at Raipur, Patan, Gurur, Dhamtari and Kurud are shown in Fig. A. Statistical analysis of 20 years gauge – discharge and rainfall data was carried out in MS Excel.

Topographical and geomorphological characteristics of the study area were explored by using the combination of Survey of India toposheets No. 64-G and 64-H on 1:250,000 scale. Analysis revealed that Kharun catchment drains from south to north and north-east. Maximum and minimum elevation in the study area is 427 m and 271 m above the mean sea level, respectively. Streams of the catchment were delineated and ordered according to Strahler's (1957) ordering scheme. The methodology suggested by Chow (1964) was used for quantification of the important geomorphological parameters.

■ RESULTS AND DISCUSSION

Rainfall record of station Patan (1990, 1991, 1992, June 1996, January – April 1997 and September – October 2007) and Gurur (September – October 2007) were missing for the period as shown in parentheses. To complete the data, average annual rainfall of these stations were compared with the average annual rainfall of nearby stations *viz*., Balod, Raipur, Bhatagaon, Dhamtari, Kurud, Rudri and Kharkhara. As the variation is more than 10%, hence, normal rainfall ratio method was used and missing data were generated. Weighted rainfall for the study area was then estimated by constructing the Thiessen polygons as shown in Fig. A. The calculated weights of each raingauge station, starting from rainfall station one to five (Patan, Gurur, Dhamtari, Kurud and Raipur) were found to be 0.33, 0.18, 0.11, 0.15 and 0.23, respectively. It can be seen from the rainfall data (Fig. 1) that the monsoon rainfall occurs from June to October, and this period was considered as the active rainfall period (June 1st to October 31st) of the year. The analysis of gauge – discharge and rainfall data show that runoff – rainfall ratio in reported years varied between 0.1487 in year 2002 to 0.5118 in year 1994, averaging 0.3444 for the 20 years (Fig. 2). The same ratio considering the active period only (June

Table 1 : Geomorphological parameters of Kharun catchment for different stream orders

Stream order	Total number of streams	Mean stream length (km)	Mean stream area (km^2)	Bifurcation ratio	Stream length ratio	Stream area ratio
(w)	(N_w)	(L_w)	(A_w)	R_B	R_L	R_A
1	206	4.25	9.77	5.7	-	-
2	36	8.3	91.6	6	1.95	9.37
3	6	24	637	3	2.89	6.95
4	2	35	2043	2	1.45	3.2
5	1	3.5	4118	-	0.1	2.01

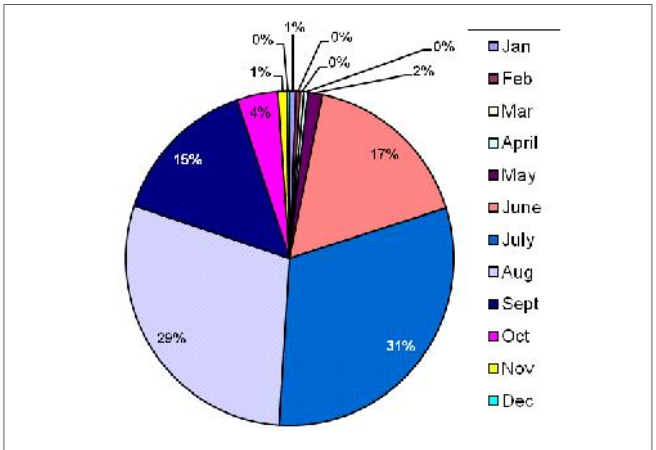

Fig. 1 : Average monthly distribution of rainfall

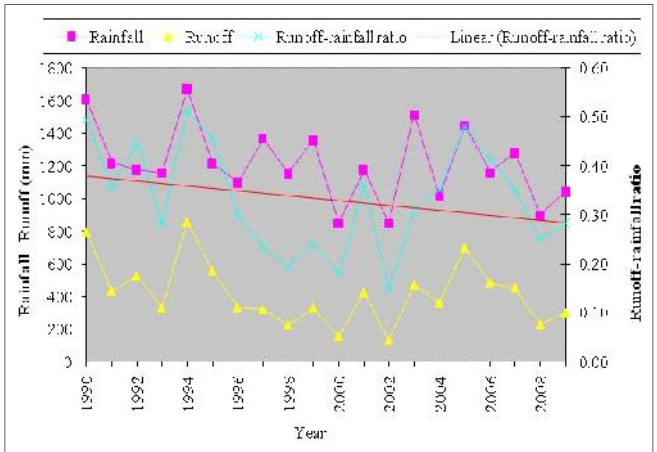

Fig. 2 : Annual Hydrological behaviour

Table 2 : Important linear and areal parameters of the catchment

Parameters	Notation	Value on scale 1:250000
Perimeter of the basin	P	351 km
Mean length of watershed	L	112 km
Mean width of watershed	W	69 km
Elongation ratio	R_e	0.65
Circularity ratio	C_r	0.42
Bifurcation ratio (Basin)	R_{BA}	3.87
Stream length ratio (Basin)	R_{LA}	1.1
Stream area ratio (Basin)	R_{AA}	4.56
Form factor	R_f	0.33
Stream frequency	F	0.06 per sq. km
Slope of main stream	S_L	0.00095

to October) is 0.3483, indicating the effect of saturation. The stream flow in no rainfall period also shows the delayed and ground water response of the catchment. It is observed from Fig. 2 that the catchment behaviour to infiltration and other losses and also the fluctuating runoff to rainfall relationship.

Kharun catchment is a fern shaped catchment and the river almost divides it into two equal halves. Drainage network map of the catchment was prepared and different geomorphological parameters like: - stream order (w), total number of streams (N_w), mean stream length (L_w), mean stream area (A_w), bifurcation ratio (R_B), stream length ratio (R_L), stream area ratio (R_A) were worked out and is shown in Table 1. Some important linear and areal parameters of the catchment are shown in Table 2. As seen from Table 1 Kharun catchment is a 5^{th} order basin. Slope is very gentle, which increases the time of concentration. Bifurcation ratio of the catchment was 3.87, which shows that on an average there are 3.87 times more tributaries of lower order as compared to a stream of given order.

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