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DEGRADATION AND STREAM CAPACITY ON KROL ROCKS DURING MONSOON RAINS : ILLUSTRATION FROM A HIMALAYAN WATERSHED

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ABSTRACT : The paper concentrates and highlights on a problematic aspect i.e. the stream capacity and degradation of the Krol rocks during monsoon rains which postulates that : (i) stream discharge and silt delivery are largely effected by monsoon rains. (ii) 1 mm monsoon rain produces 1.40' 000 ha m/km^2 water discharge, and (iii) 2 mm monsoon rain generates 0.58 ha m/km^2 silt delivery as expressed by the allometric models constructed by integrating regression analysis between stream discharge (Q) and rainfall (R), and silt delivery (S) and rainfall (R):

$$Q = 0.28 + 1.12 (R) \text{ ' } 000 \text{ ha m/km}^2$$

$$S = -3.90 + 2.24 (R) \text{ ha m/km}^2$$

INTRODUCTION

The Lesser Himalaya, lying north of the outermost chain of Himalayan system known as the Siwaliks, is passing through a very young stage of geomorphic development (Rawat and Joshi, 1982, p. 183) and is built up of Pre Cambrian and Palaeozoic rocks comprising of three major nappies (Fig. 1 A and B) viz. the Krol, the Ramgarh and the Almora alongwith their many klippen (Valdiya, 1978, p. 2). These nappies are dissected by a large number of deep seated transverse and oblique faults (Valdiya, 1976) The fundamental aim of the present paper is to present the volumetric indices of the stream networks of the Krol rocks by relating stream capacity to the monsoonal rains. In order to relate channel character to the monsoonal rains, a drainage basin extending over the Krol rocks has been selected which also has a hydrological station located at its mouth.

LOCATION

The study confines to the basin of river Mandal that stretches between 29^o 40' and 29^o 50' North Latitudes and 78' 45' and 78' 57' East Longitudes (Fig. 1 C) and encompassing 286.19 sq. km. of planimetric area. The Mandal is one of the principal tributaries of the Western Ramganga that drains a large area in the south-central sections of U. P. Himalaya. The study basin entirely falls in the district of Pauri and also has a hydrological station at Maidabani (Fig. 1 C) that records the stream discharge, silt delivery as well as rainfall.

TABLE 1 : STRATIGRAPHICAL FORMATIONS AND LITHOLOGY OF THE MANDAL BASIN

Tectonic Unit	Stratigraphical Formation	Lithology
	Kophara	Shale, List (black), List. Carbonic Shales
The Krol	Subathu	Red Shale, List.
	Lower Tal	Shale (blackish), Conglomerates
	Krol	List., Red/Green Shale
	Blaini/Infra Krol	Fluxoturbide, List., Sandstone, Slates
	Nagthat	Orthoquartzites, Grits, Shale, Grey-wacks, Silts

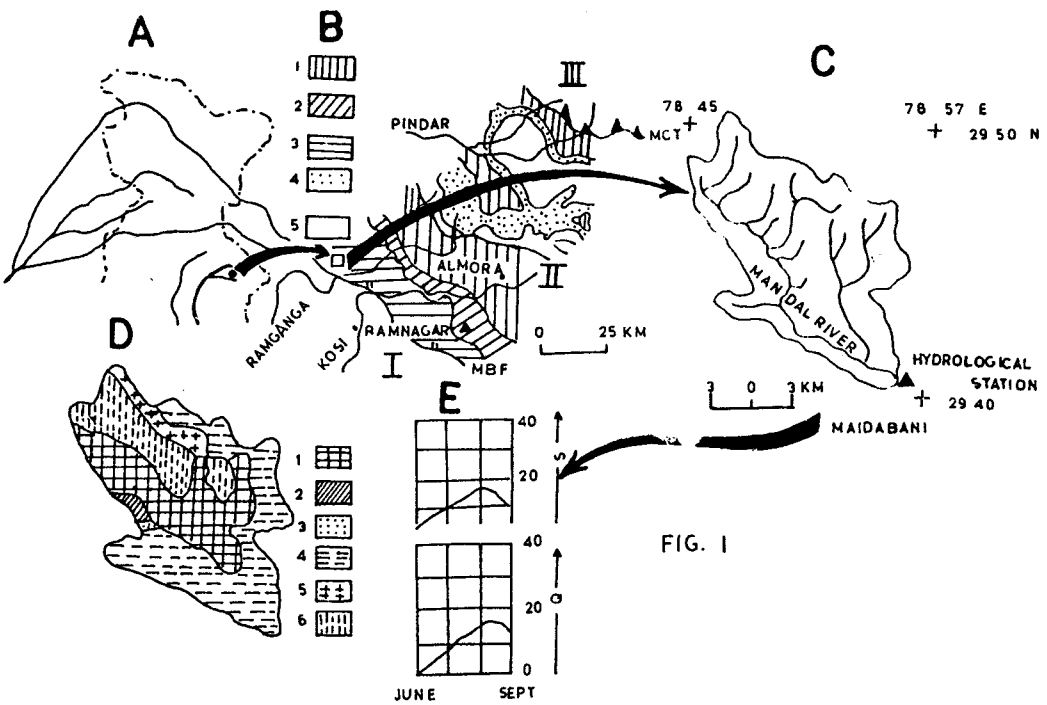

FIG. 1

Fig. 1 A. Location of Study Area in India

B. Location of Study Area in Central U. P., Himalaya
I – Siwaliks, II – Lesser Himalaya, III – Greater Himalaya
1. Almora Nappes, 2. Ramgarh Nappes, 3. Krol Nappes, 4. Jaunsar–Berinag Nappes, 5. Autochonous

C. Mandal River Basin

D. Geology of the Mandal River Basin
1. Kophara formation, 2. Subathu, 3. Lower Tal, 4. Krol, 5. Blaini/Infra Krol, 6. Nagthat.

E. Hydrograph and corresponding silt graph during monsoon rains (1977–82)
Q Stream discharge in 1000 ha m/Km^2
S Silt in ha m/Km^2

ROCKS

The rocks of the Mandal basin are divisible into six different stratigraphical formations (Fig. 1 D) viz. the Nagthat, the Blaini/Infra Krol, Krol, Lower Tal, Subathu and Kophara (Table 1).

HYDROMETRIC PARAMETERS

The hydrograph with corresponding siltgraph (Fig. 1 E) of the Mandal basin for the monsoonal rains (June to September) reveal the following salient hydrometric characteristics :

1. June is the month of approaching segment of the discharge and silt graph.
2. July is the month that corresponds with the rising segment of hydrograph.
3. July is the month of peak water discharge, followed by peak silt flow.
4. September is the month of recession segment where the surface water inflow decreases followed by silt delivery.

The mean (running six years, 1977-1982) stream discharge of the drainage basin during rainy season stands at 48068.5 ha m/km^2 coupled with 16.5232 ha m/km^2 silt delivery (Table 2).

MORPHOMETRIC PARAMETERS

The rocks of the Krol tectonic unit are passing through young stage of geomorphic development (Rawat and Joshi, 1982). There are as many as 193 streams ($\lesssim$ N) in the Mandal basin with a total stream length ($\lesssim$ L) and basin area (Ab) of 1152.19 km and 286.19 km2 respectively. Drainage density and stream frequency as a product of $\lesssim$ L and Ab, and $\lesssim$ N and Ab, stand at 4.03 km/km^2 and 6.96 no/km^2 respectively. The drainage basin is largely distorted and has low relief ratio as evidenced by low basin circularity ratio (Cr = 0.155) and relief ratio (0.06 m/km) (Table 2).

RAINFALL

The compound columnar hyetograph (Fig. 2) shows the mean monthly, extreme maximum, extreme minimum and most centrally placed (75%) observations of rainfall during the rainy season between 1973 and 1982. This suggests that the mean annual rainfall is 125.7 mm at Maidabani. The mean annual rainfall intensity stands at 15.56 mm/day which approaches upto 23.72 mm/day in September and drops to 7.66 mm/day in the month of November.

EFFECT OF MONSOON RAINS ON STREAM DISCHARGE AND SILT DELIVERY

In order to obtain the effect of monsoonal rains on water discharge and silt delivery of the Krol rocks, correlation and regression analysis were adopted to measure the association and to compute the allometric rates of change between these parameters respectively.

CORRELATION

Correlation coefficients were computed (Chapman, 1976) between stream discharge and rainfall, and silt delivery and rainfall by using the data for the period 1977 to 1982. The results (Table 3) suggest that the stream discharge and silt delivery are strongly positively correlated with rainfall which are significant at more than 95% confidence level.

ALLOMETRIC CHANGE

The relative rates of change viz. the allometric change (Woldenberg, 1966, 1972; Wilson, 1969; Faulkner, 1974) between stream discharge and rainfall, and silt delivery and rainfall were computed by integrating

TABLE 2 : HYDROMETRIC AND MORPHOMETRIC CHARACTERISTICS OF THE MANDAL BASIN.

Sl. No.	Parameters	Value
1.	Mean discharge*	48068.05 ha m/km^2
2.	Mean silt delivery*	16.5232 ha m/km^2
3.	Drainage density	4.03 km/km^2
4.	Stream frequency	6.96 No/km^2
5.	Basin area	286.19 sq. km.
6.	Total number of streams	1993
7.	Total stream length	1152.19 km
8.	Basin circularity ratio	0.155
9.	Relief ratio	0.06 m/km

* Mean of six running years (1977–1982).

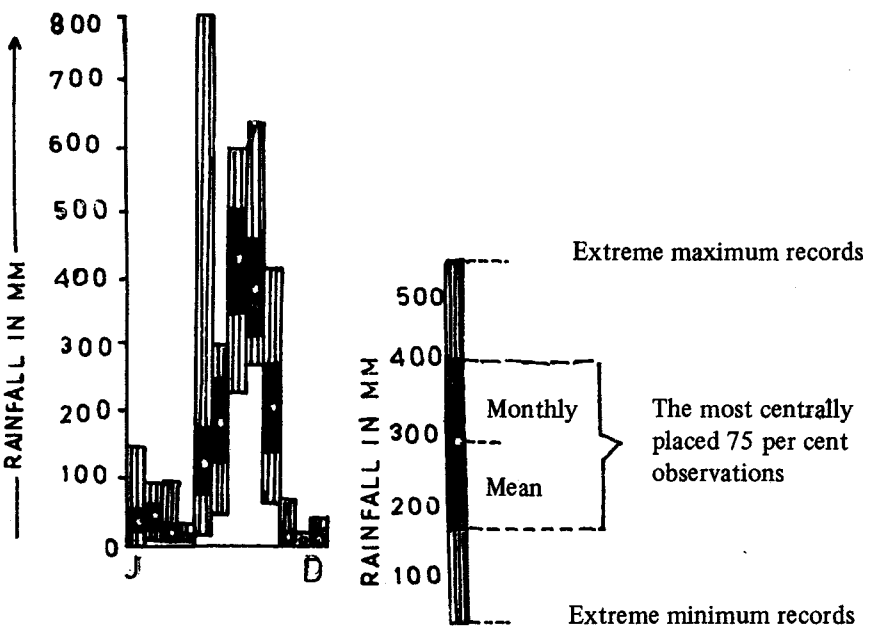

Fig. 2 : Compound Columnar Hyetograph for Maidabani

the regression analysis between these parameters. The results are presented in Table 3 and diagrammatically illustrated in Fig. 3.

INTERPRETATION

The allometric model constructed between stream discharge and rainfall reveals that a unit (i.e. 1 mm) increase in rainfall (R) produces 1.40, 000 ha m/km^2 water discharge (Q) in the Mandal basin.

$Q = 0.28 + 1.12$ (R), 000 ha m/km^2
placing the value of 'R' = 1 mm.
$Q = 0.28 + 1.12$ (1 mm)
$= 1.40$ ' 000 ha m/km^2

Similarly, the rates with other rainfall figures may be obtained by the above allometric model.

The allometric model constructed between silt delivery (S) and rainfall (R) reveals that 1 mm of rainfall over the Krol rock does not produce any silt load since it percolates completely. 2 mm rainfall, however, produces 0.58 ha m/km^2 silt load from these rocks:

$S = -30.90 + 2.24$ (R) ha m/km^2
placing the value of 'R' = 2 mm
$S = -2.90 + 2.24$ (2 mm)
$= 0.58$ ha m/km^2

Similarly, the rates at other rainfall amount may be computed by the above allometric model.

In addition, the allometric model constructed between stream discharge (Q) and silt delivery (S) also indicates that 3,27,000 ha m/km^2 water discharge is generating 1 ha m/km2 of silt delivery from the Krol rocks:

$Q = 0.42 + 2.85$ (S)' 000 ha m/km^2
placing the value of 'S' = 1 ha m/km^2
$Q = 0.42 + 2.85$ (1)
$= 3.27$' 000 ha m/km^2

CONCLUSIONS

The experimental study of the Mandal basin extending across the Krol rocks, in the south central sections of U.P. Himalaya highlights the following geomorphohydrostistical characteristics of the Krol rocks in the Himalaya.

1. The Krol rocks are passing through a young stage of geomorphic development demonstrated by the high values of drainage density and stream frequency.
2. Stream discharge and silt delivery are largely controlled by monsoonal rains.
3. 1 mm monsoonal rain produces 1,40'000 ha m/km^2 water discharge in the Krol rocks.
4. 1 mm monsoonal rain does not degrade the Krol rocks possibly due to their permeable nature.
5. 2 mm monsoonal rain degrades the Krol rocks to the extent of 0.58 ha m/km2
6. The allometric models (Table 3) that suggest the relative rates of change between stream discharge and rainfall, and silt delivery and rainfall can have a wide application to infer and estimate the stream capacity and degradation of Krol rocks in the Himalayan region, specially during the monsoon period.

TABLE 3 : CORRELATION COEFFICIENT AND REGRESSION MODEL BETWEEN STREAM DISCHARGE (Q), SILT DELIVERY (S) AND RAINFALL (R).

Regression Model	Correlation Coefficient	Significant Level
$Q = 0.28 + 1.12\ (R)$' 000 ha m/km^2	0.792	95%
$S = -3.90 + 2.24\ (R)$ ha m/km^2	0.856	95%
$Q = 0.42 + 2.85\ (S)$' 000 ha m/km^2	0.821	99%

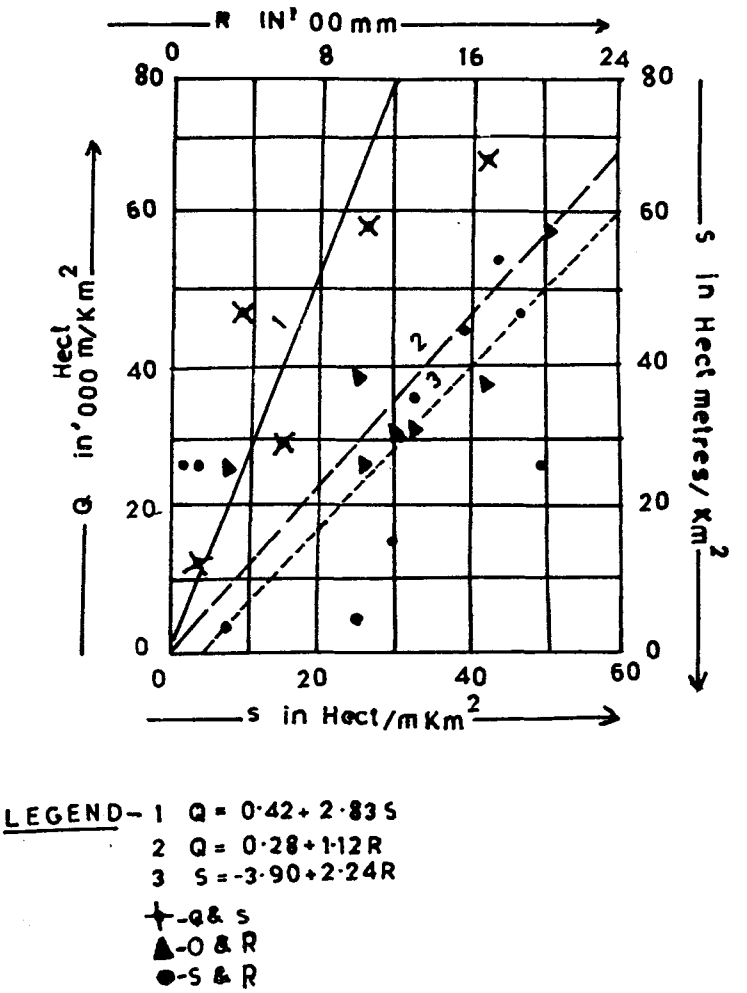

Fig. 3 : Regression Model between Stream Discharge (Q) and Silt (S); Stream Discharge (Q) and Rainfall (R) and Silt (S) and Rainfall (R).

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