International Symposium on
Hydrology of Mountainous Areas
Shimla (INDIA) May 28-30, 1992

Rainfall-Runoff Study of Vamshadhara Basin for Improved Flood Forecasting

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ABSTRACT

A simulation study of rainfall-runoff relationship of the typical hilly catchment of Vamshadhara River has been made, because of its flashy nature, its limited data availability and influence of coastal storms etc. Synthetic Unit Hydrographs were used in this black box model, with rainfall, runoff and topographical data, to forecast flood hydrographs and improved flood warning method.

INTRODUCTION

A simulation model, within concept of black-box model has been developed, taking into consideration drainage basin characteristics, rainfall data and runoff data of about 8 years duration, for improvement in flood warning methods to the downstream flood effected reaches, where flood disasters are very high.

The study is aimed at determining the flood hydrographs, peaks and time lags from Minazole (Fig.1) to Khasinagar stations on main reaches of river, discharge data being available only at the later station.

THE PROBLEM

The flood problem of river is peculiar due to flashy floods of varying magnitudes, causing great devastation. The worst flood was of Sept. 22, 1980, which caused very extensive damages, apart from the one of Sept. 22, 1972. The catchment area at Gunupur is only 6740 sq. kms (the first stage forecasting station of C.W.C. presently): while at Khasinagar it is 10830 sq. kms being joined by major tributaries downstream.

SPECIAL HYDROLOGICAL PROBLEMS OF THE BASIN

Vamshadhara River basin has special characteristics for runoff study. Originating at an altitude of 100 m, the river has hilly ranges on its major tributary catchments, at elevations 6000 m to 1000 m, while the main river itself begins at an elevation 100 m. Sharply rising hill ranges known as Eastern Ghats, deflect the rain-making clouds into the basin, which drains into their originating sea; Bay of Bengal.

The phenomena of rainfall is unique for the catchment, being nearer to the sea coast, the proximity of which maximises rainfall by orographic effect and also being in the path of the frequently visiting cyclones, depressions and the south-west monsoon winds, which all contribute to the major runoff.

The isohyetal patterns of rainfall are also very highly concentrated on the left side and the hilly catchments of the tributaries, which contribute to major floods at different points of the main river. The existing 7 nos or so of the rain gauges are extremely insufficient, for estimation of rainfall volumes, even by the M.M.O. standards for the hilly catchments.

The other very unusual physical characteristics of the basin are (1) the left side tributaries (forming largest basin area) contribute to the large flashy floods, they have typical and regular steep valleys, very steep channel slopes etc., which cause significant problems for the development of Synthetic Unit Hydrographs for this very insufficiently gauged basin.

The general characteristics of the basin are; Longest stream 221 kms, axial length of basin 120 kms with average width 65 km basin perimeter 405 kms, basin fan shaped with average annual discharge of 3500 million cubic meters.

The major constraint for the application of the unit hydrograph technique is the very uneven distribution of rainfall over the entire basin. Typical example of daily rainfall (in mm) on 17-9-80 is (Fig.1) Gudari 62.8, Gunupur 83.4, Mohana 253.0, R.Udayagiri 197.0, Parlakhisudi 74.2, Bissam Cuttack 222.0 and Gotta 123.

STUDY OF THE MODEL

The basin is divided into six subbasins: (1) area A, contains farthest tributaries to the right side and U/S of Minazole (2) area containing tributaries farthest and to left side B U/S of Minazole (3) area C containing tribaturies U/S of Gudari; (4) area containing tributaries Gangudu etc U/S of Gunupur; (5) area containing tributories Sannanadi etc U/S of Kashinagar; (6) area containing tributaries Mahendratanaya etc U/S of Gotta.

The following Synthetic Unit Hydrograph equations are used:

$$t_p \text{(peak lag time hrs)} = 0.376 \left[\frac{L.L_c}{\sqrt{S}}\right]^{0.434} \quad \ldots. (1)$$

with the usual connotations

$$q_p \text{ (discharge per unit area)} = 1.215/(t_p)^{0.691} \quad \ldots. (2)$$

$$W_{50}\text{(width of SUH at 50\% peak)} = 2.211/(q_p)^{1.07} \quad \ldots. (3)$$

W_{75}(width of SUH at 75% peak)=$1.312/(q_p)^{1.003}$ .... (4)

T (time base of SUH hrs) = $7.621\ (t_p)^{0.623}$ .... (5)

These are based on the Central Water Commission Manual for the basin hydrometeorological zone 4b and their workshop 1086 at Bhubaneswar.

After estimating the losses for different rainfalls, from the soil characteristics and topographical characteristics of each basis, the expected flood hydrograph is determined for each sub-basin and all of these hydrographs are routed through the different reaches of main river chronologically downstream upto Kashinagar.

For flood routing Muskingun Equations are used in its linear form and other nonlinear forms also (Table).

For easy calculation and comparison the Muskingun coefficients K and as derived from the following linear form used although other Muskingun parameters are also determined.

$$S \pm K [xI + (I-X)Q] \quad \text{.... (6)}$$

The variables have the usual connotation.

RESULTS AND DISCUSSION

The SUH parameters for each sub-basin are given in Table II and the Flood Routing Parameters are given in Table II & V for the three reaches between Minazole, Gudari, Gunupur and Khasinagar.

Graphs of the Synthetic Unit Hydrographs for each sub-basin are given in Figures 1, 2, 2a, 3, 3a for 24 hours and also for 1 hour.

Thirteen critical flood hydrographs are analysed for entire basin. The results of the model values, observed values for the flood peaks; the times of travel for the above three reaches of river along with calculated runoff coefficients are all given in seperate tables for these 13 storms.

CONCLUSIONS

The estimated flood peaks are within reasonable degree of error as seen from tables. From the nature of flood peak range it could be seen that the time of travel for each flood peak is different and decreases with increase in peak value for the reaches of river.

The above results of study can be used for correctly knowing the warning time for expected peak range. Also the corresponding times of travel for an expected flood can be known by interpolation and therefore the Muskingun routing parameters for the forecasting of full hydrograph.

The results of three such forecasts are given in graphs (Figure 3.4.)

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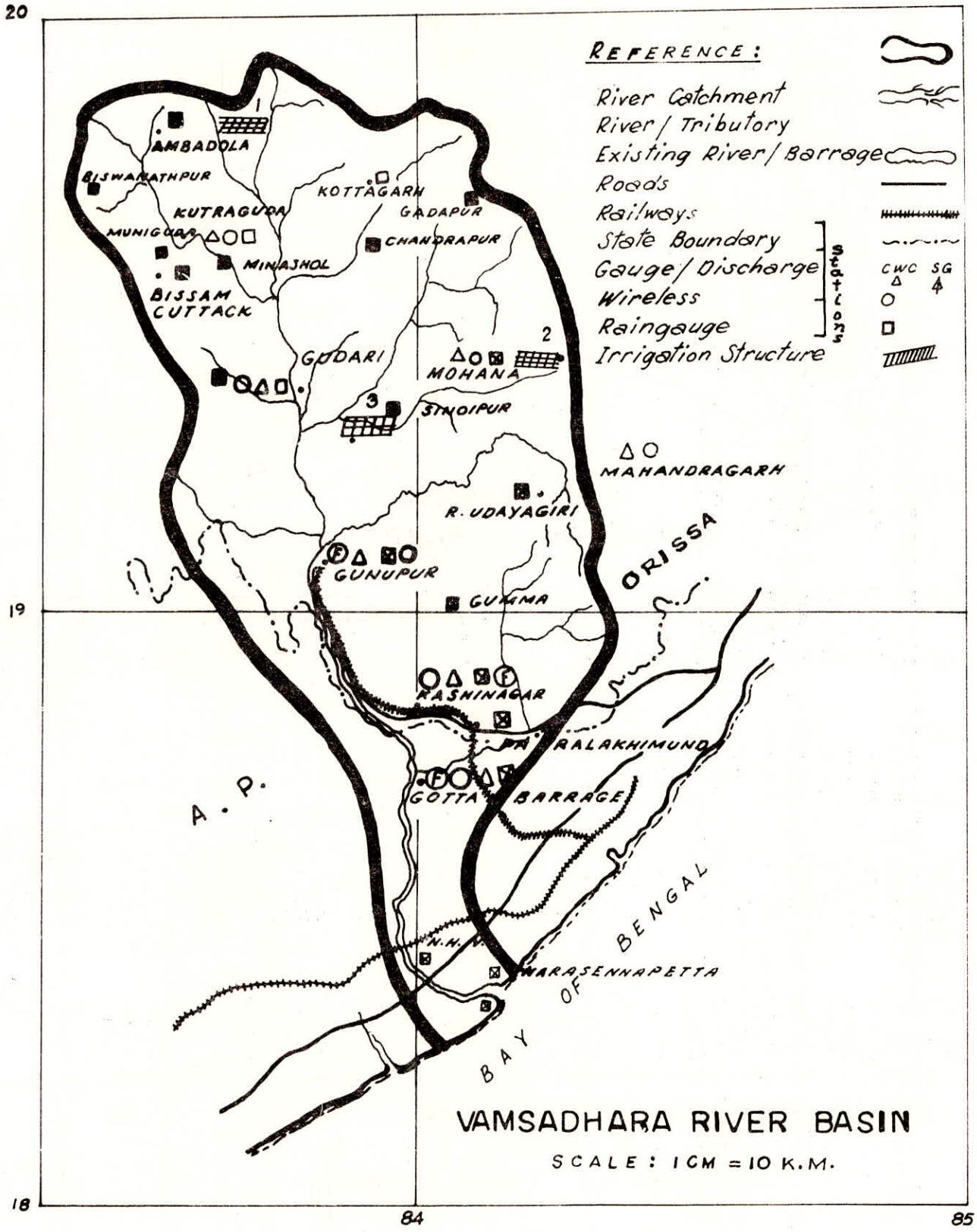
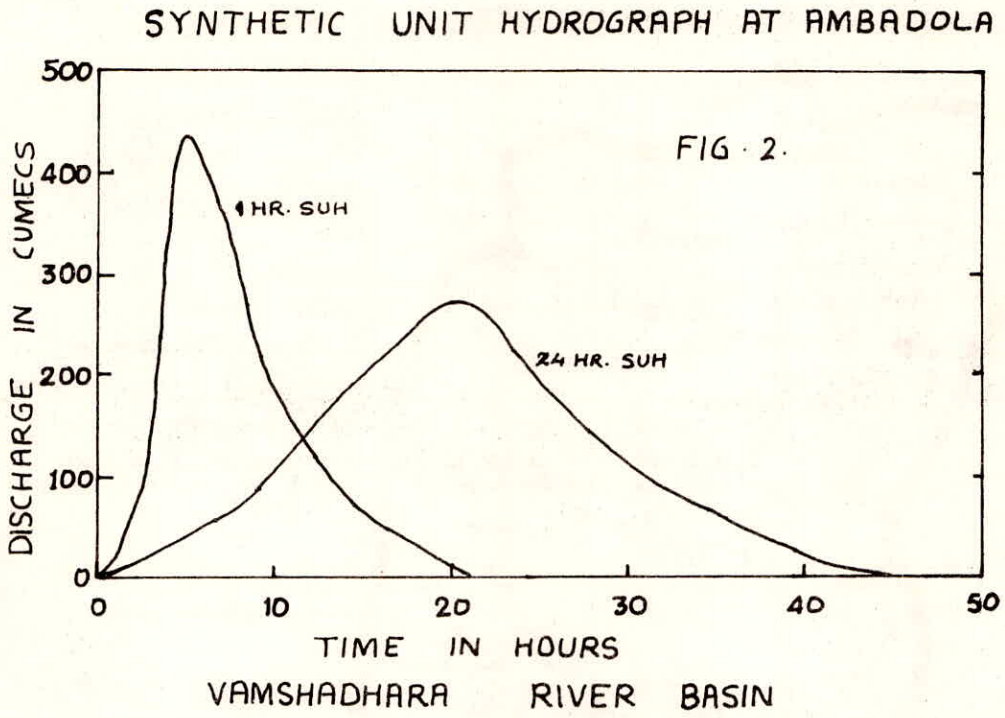
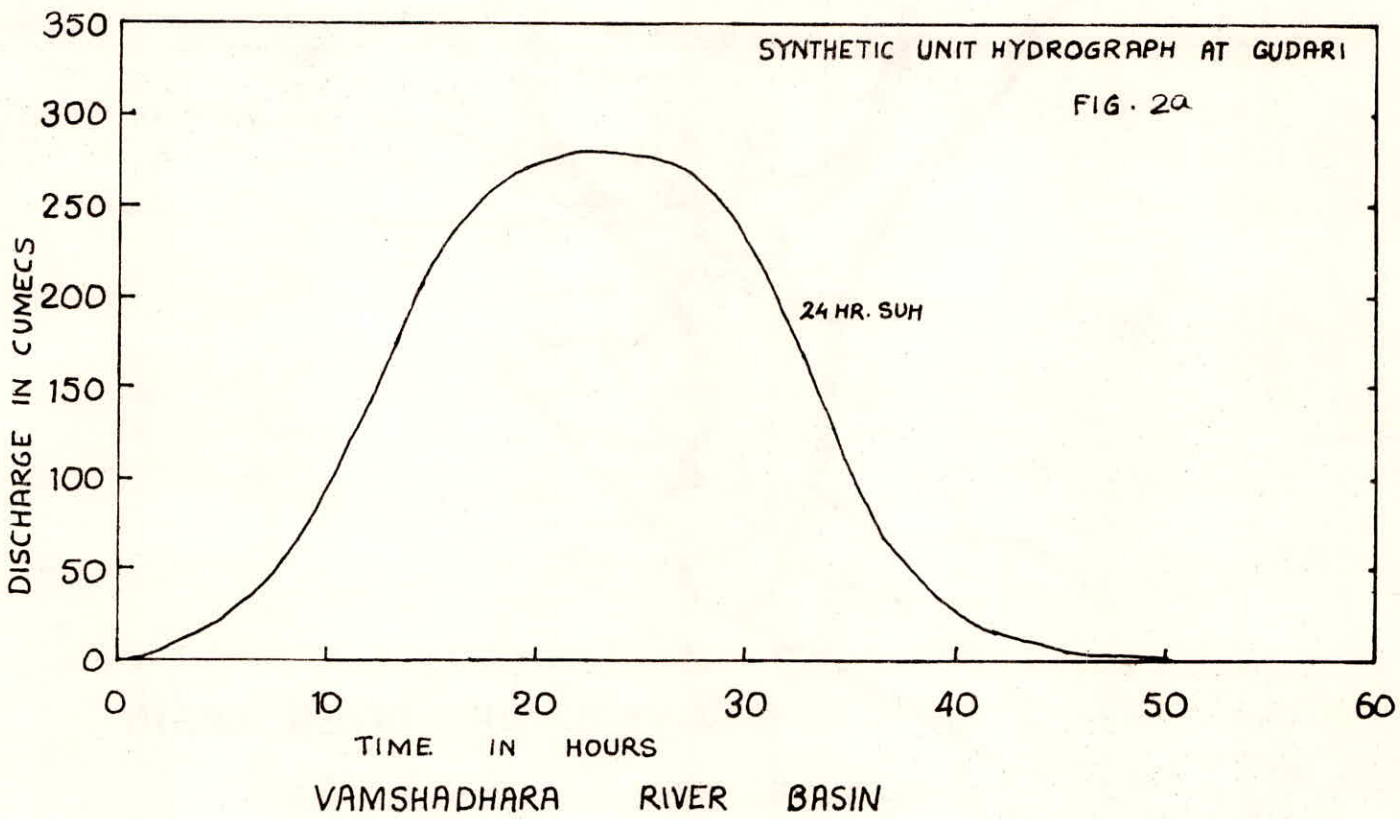
DISCUSSION

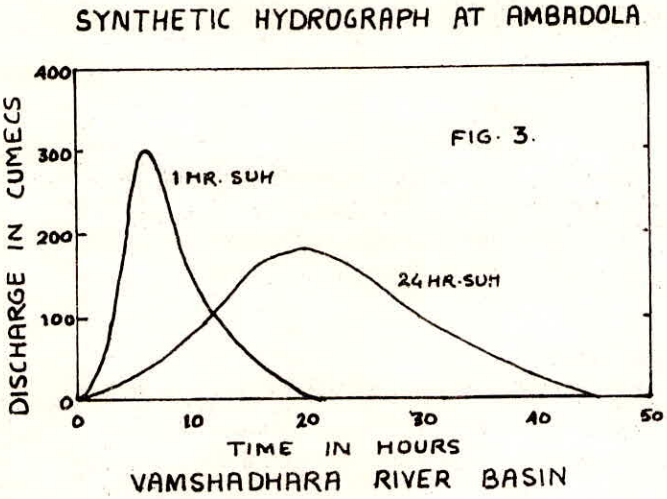
S. M. SETH : What is the size and time of concentration for the hilly catchment of Vamshadhara river ? How rainfall data was obtained/used for hourly or lesser period in such study ?

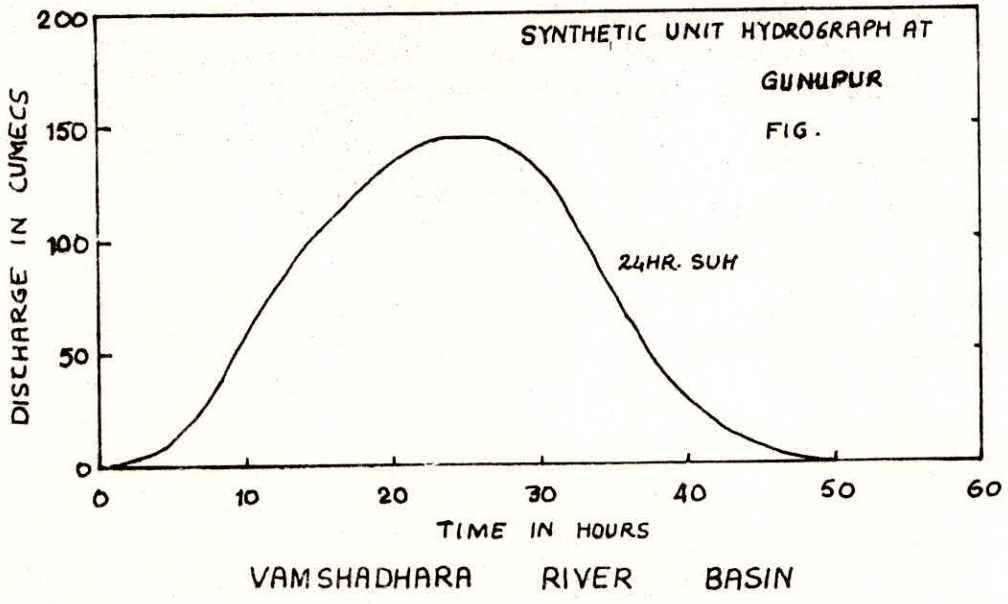
AUTHOR(S) :
Total Catchment area of Vamshadhara River = 10830 sq.km.
Maximum Length of the stream = 221 km.
The time of concentration depends upon the rainfall intensity and the stream discharge.
The average values of the times of of travel between the mainstream stations given in Fig.2 are as follows from Guderi station.
Guderi - 0 hours
Gunupur - 3 hours
Kashinagar - 4 hours
Gotta - 8 hours


20
19
18
84
85
REFERENCE :
River Catchment
River / Tributory
Existing River / Barrage
Roads
Railways
State Boundary
Gauge / Discharge
Wireless
Raingauge
Irrigation Structure
Stations
CWC
SG
1
2
3
AMBADOLA
BISWANATHPUR
KOTTAGARH
KUTRAGUDA
GADAPUR
MUNIGUDA
CHANDRAPUR
MINAJHOL
BISSAM CUTTACK
GUDARI
MOHANA
SINGIPUR
MAHANDRAGARH
R. UDAYAGIRI
GUNUPUR
GUMMA
ORISSA
RASHINAGAR
PALAKHIMUNDA
GOTTA BARRAGE
A. P.
N.H.
MARASENNAPETTA
BAY OF BENGAL
VAMSADHARA RIVER BASIN
SCALE : 1 CM = 10 K.M.


SYNTHETIC UNIT HYDROGRAPH AT AMBADOLA
FIG · 2.
1 HR. SUH
24 HR. SUH
DISCHARGE IN CUMECS
500
400
300
200
100
0
0
10
20
30
40
50
TIME IN HOURS
VAMSHADHARA RIVER BASIN


SYNTHETIC UNIT HYDROGRAPH AT GUDARI
FIG · 2a
24 HR. SUH
DISCHARGE IN CUMECS
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
TIME IN HOURS
VAMSHADHARA RIVER BASIN


SYNTHETIC HYDROGRAPH AT AMBADOLA
FIG. 3.
1 HR. SUH
24 HR. SUH
DISCHARGE IN CUMECS
400
300
200
100
0
0
10
20
30
40
50
TIME IN HOURS
VAMSHADHARA RIVER BASIN


SYNTHETIC UNIT HYDROGRAPH AT
GUNUPUR
FIG.
24HR. SUH
DISCHARGE IN CUMECS
200
150
100
50
0
0
10
20
30
40
50
60
TIME IN HOURS
VAMSHADHARA RIVER BASIN