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HYDROLOGICAL CHARACTERISTICS OF SARDAR SAMAND RESERVOIR IN ARID RAJASTHAN

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ABSTRACT

Long term results of measured hydrological data of Sardar Samand reservoir in arid region of Rajasthan and its 1634.11 km² catchment area are reported. Most of the inflow to the reservoir occurred in response to few high magnitude rainfall of more than 50 mm in the catchment and ranged from 0.1-10% depending upon its magnitude. The number of such flow ranged from 5 to 12 in a year. However, the annual runoff ranged from 1.2—6.8%. In 10 out of 12 years the water yield was less than 25% of the reservoir capacity. The coefficient of variation of the annual runoff and rainfall was 98% and 86%, respectively.

INTRODUCTION

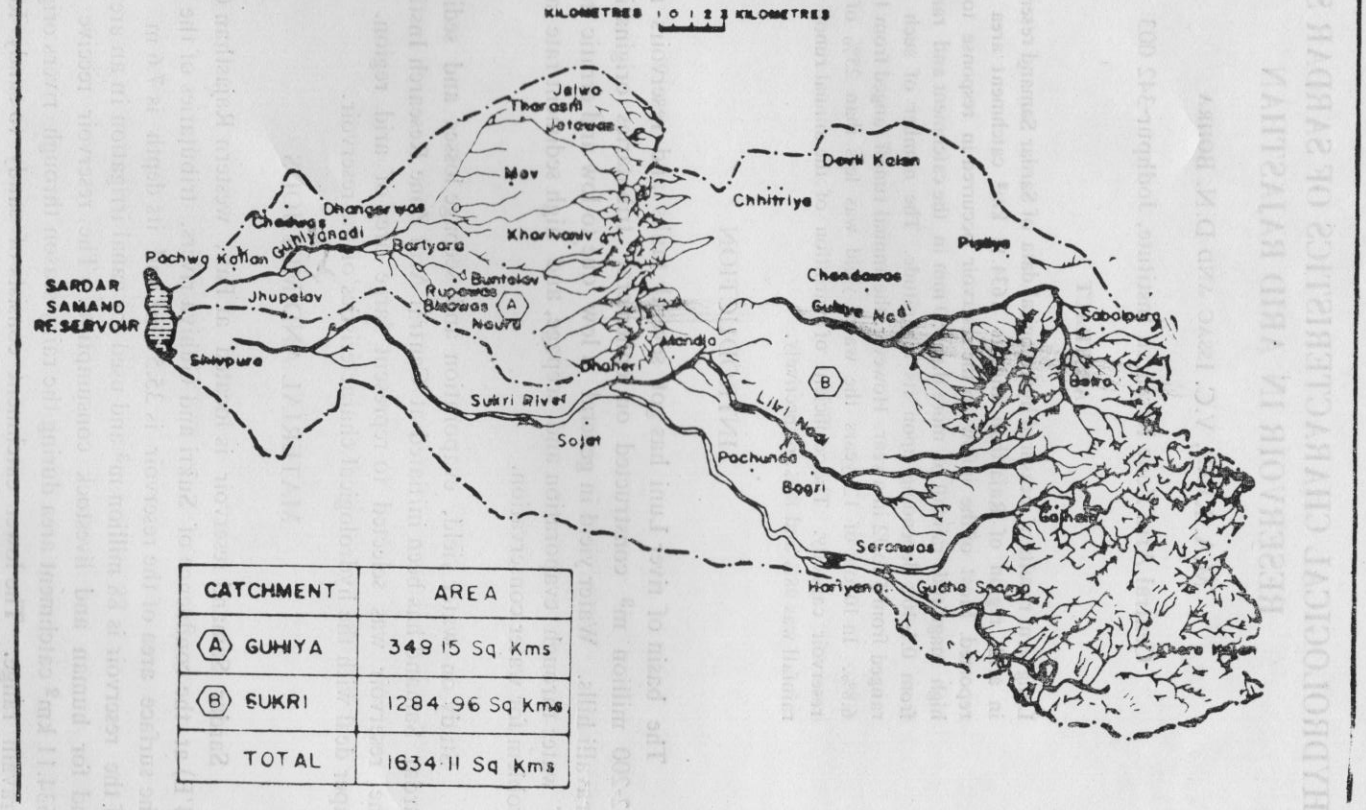
The basin of river Luni has got several tanks and reservoirs ranging from 0.2-200 million m^3 constructed on ephemeral tributaries originating from the Aravalli hills. Water yield in general is low due to low and erratic rainfall. Loss of water through evaporation and seepage, and high sediment rate are the serious problem for water conservation.

Study on water yield, evaporation and seepage losses and sedimentation of Sardar Samand has been initiated at Central Arid Zone Research Institute Jodhpur. The reservoir was selected to represent large area of arid region. The present paper deal with the hydrological characteristics of the reservoir.

MATERIAL AND METHODS

Sardar Samand reservoir is located at Pali, western Rajasthan (25°56'N, 73° 24'E) at the confluence of Sukri and Guhiya rivers, tributaries of the Luni (Fig. 1). The surface area of the reservoir is 35.5 km^2 and its depth is 7.6 m. The capacity of the reservoir is 88 million m^3 and used for canal irrigation in an area of 1300 ha, and for human and livestock consumption. The reservoir receive water from a 1634.11 km^2 catchment area during the rainy season through rivers originating from Aravalli range. The lower catchment consists of sandy to sandy loam soils with compact zone of lime concretion at depth ranging from 0.5 to 1.0 m. The infiltration rates are high but water storage capacity is low.

FIG.1 CATCHMENT AREA OF SARDAR SAMAND RESERVOIR



CATCHMENT	AREA
(A) GUHIYA	349 15 Sq Kms
(B) SUKRI	1284 96 Sq Kms
TOTAL	1634 11 Sq Kms

The average annual rainfall at Pali is 380 mm, with coefficient of variation of 40-70%. About 80% of the annual rainfall is received from June to September. The annual mean maximum and minimum temperature are 33.8 °C and 18.7 °C, respectively. The annual evaporation (3072 mm) far exceeds the precipitation.

Data on reservoir water level from 1977 to 1988 were ascertained from records of daily vertical staff gauge readings. Rainfall data were obtained from rain gauging stations established in the area and average value was used in this study. The inflow in the reservoir was determined by the following relationship :

$$Dwi = \triangle Bw + Lw + Dwo + Uw - Pw$$

where

Dwi = inflow discharge from the catchment area into the reservoir
$\triangle$Bw = change of water level
Lw = water loss due to evaporation and seepage
Dwo = overflow discharge from the reservoir
Uw = water consumed by the livestock
Pw = precipitation falling on the reservoir

The losses through evaporation and seepage were determined by the standard method of water budget. Water consumed by the livestock (Uw) was negligible therefore ignored. The change in water level ($\triangle$Bw) was subsequently converted into water depth in mm over the catchment area with the help of stage capacity chart. The daily values were summed up to give the annual water yield.

RESULTS AND DISCUSSION

Runoff characteristics

Most of the inflow to the reservoir occurred in response to few high magnitude rainfall of more than 50 mm in the catchment and ranged from 0.1-10% depending upon its magnitude. The number of such flow ranged from 5-12 in a year. In majority of the cases there were definite rainfall spells which continued for 3-4 days or even more making it difficult to isolate the effect of individual storm on runoff. Similar results have been reported for arid region of south west of the United States (Patterson 1962; Osborn & Lane, 1972; Renard, 1977; Osborn, 1983).

Runoff on annual basis ranged from 1.2% (2.0 mm) when the rainfall was 127 mm and 6.8% (64.0 mm) for 943 mm rainfall. There is general trend of increase in runoff with higher rainfall. However, this may not be true in all the cases as runoff rate depends upon rainfall characteristics such as magnitude, duration, frequency of occurence and distribution (Linsley et al. 1975).

Variability of rainfall and runoff

The frequency of occurrence of rainfall and runoff in various range group during the study period are presented in Table 1. The water yield in 10 out of 12 years was less than 25% of the reservoir capacity. The reservoir outflowed only during abnormally high rainfall years of 1979 and 1983. In both the years the annual rainfall was about 1000 mm. The variability of rainfall and runoff is very high and lack consistancy both in magnitude and in ratio. The coefficient of variation of annual rainfall and runoff are 98% and 86%, respectively.

Table 1. Frequency distribution of runnoff and rainfall

Runoff					Rainfall			
Group	Percentage of reservoir capacity	No.	Percentage	Cumulative percentage	Group	No.	Percentage	Cumulative percentage
⩽5 mm	9.3	5	41.7	41.7	⩽300 mm	6	50 0	50.0
10 mm	18.6	2	16.7	58.4	400 mm	2	16.7	66.7
20 mm	37.1	3	25.0	84.4	500 mm	2	16.7	83.4
50 mm	92.9	—	—	84.4	900 mm	—	—	83.4
60 mm	111.4*	2	16.7	100.0	1000 mm	2	16.7	100.0

*Reservoir overflowed

Rainfall-runoff relationship

Annual

Values of annual runoff plotted against the corresponding values of annual rainfall on a coordinated paper exhibited curvilinear trend indicating higher runoff with increase rainfall. In order to get a straight line relationship values were transferred on a double log paper as shown in Fig. 2. The line of best fit was drawn by least square method of the form

$$Y = aX^b$$

where Y is annual runoff, X is annual rainfall, a and b are constants. The relationship obtained is highly significant with a coefficient of variation of 0.8890.

Storm rainfall

Based on the storm rainfall data rainfall-runoff relationship for the monsoon months of June, July, August-September and June-September (pooled data) were established (Table 2). The relationship obtained is highly significant. The lower value of coefficient of correlation in case of pooled data may have been due to large number of observations and variability among them.

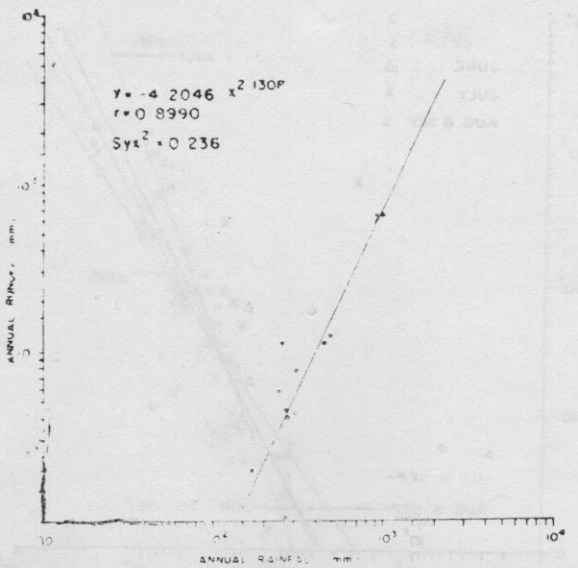


Fig 2 RAINFALL-RUNOFF RELATIONSHIP BASED ON ANNUAL DATA

Table 2. Relationship between storm rainfall and runoff

Month	No.	Regression equattion	Coefficient of correlation (r)	Variance Sxy^2
June	9	$Y^* = -3.5898\ x^{1.5386}$	0.9868	0.1284
July	25	$Y = -7.3894\ x^{2.5514}$	0.9658	0.4080
August-September	34	$Y = -4.8448\ x^{1.3366}$	0.9489	0.6080
June-September	68	$Y = -5.1589\ x^{1.9508}$	0.9198	0.1846

*Y = runoff in mm (1×10^{-2}); x = rainfall in mm (1×10^{-2})

In order to assess the effect of watershed wetness on rainfall-runoff relationship values were plotted on log paper and line of best fit were drawn (Fig. 3). The relatively flatter slope for June indicate lower value of runoff which is obvious because the watershed is generally dry during that period and consequently initial obstruction is higher. In case of July the slope of the line is steeper than that of August-September and pooled data which may be due to few extremes significantly affecting the slope of the line. The relationship obtained for August-September and pooled data are comparable. Kotoda and Mizuyama (1975) have reported similar results for lake Biwa and its catchment.

The results indicate that the water level observations obtained from the tanks and the reservoirs can satisfactorily be used to study the water yield of the area. The annual water yield is less than 6.4% and on storm basis less than 10% of the rainfall. The rainfall-runoff ratio have been found to increase in rainfall both

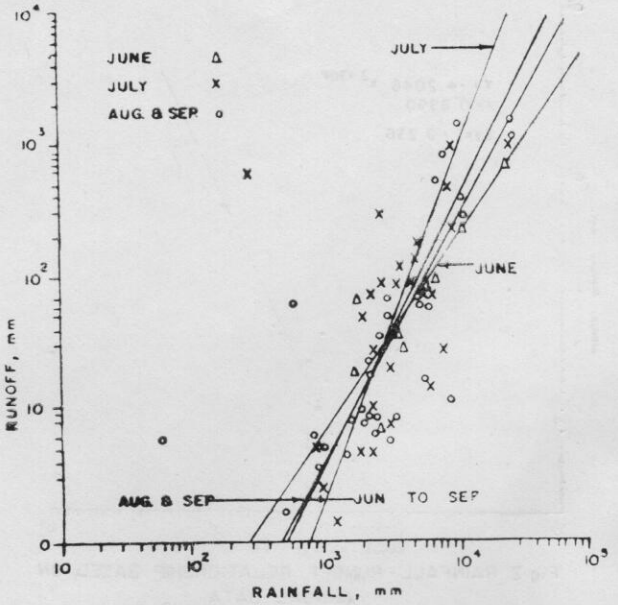


Fig. 3. RAINFALL–RUNOFF RELATIONSHIP BASED ON STORM RAINFALL DATA

annual and storm which is in confirmity with the accepted trend. The correlation obtained are reasonably satisfactory and can reliably be used for prediction of runoff from similar ungauged area to estimate the water potential.

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