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Short Comminucation

Analysis of one day probable maximum precipitation for designing soil and water conservation structures in Agra, U.P.

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The probable maximum precipitation (PMP) for a given region or area is a prerequisite for planning and designs of structures such as check dams, storage reservoirs, drainage works, irrigation tanks, building, highway bridges, etc. Also, a high density of rainfall causes large scale flooding, claiming several lives and causing property damage on enormous scale. Therefore, accurate estimates of PMP should be essential for a design engineer or a hydrologist to prevent recoverable losses (Ghahraman, 2008).

To estimate the PMP in a place a variety of procedures based on the location of the project basin, availability of data and other considerations have been proposed (WMO, 1986, Rakhecha, *et al.,* 1992; Collier and Hardakar, 1996). Most of them are based on meteorological analysis, whereas few based on statistical analysis. Koutsoyiannis (1999) developed a method for assigning a return period to PMP values obtained using the frequency factor method (Hershfield, 1965). The PMP results calculated based on two techniques were very similar for both the cases. The PMP were determined by using the Hershfield technique and Gumbel's theory of extreme values for planning soil and water conservation structures (Durbude ,2008 and Singh *et al.,* 2014).

The main objective of the present study was to estimate the PMP of one day duration for semi arid region of Central India using rainfall data of meteorological station of Indian Council of Agricultural Research- Indian Institute of Soil and Water Conservation, Research Centre (ICAR-IISWC, RC) Agra (U.P.). The daily rainfall data for 50 years (1965-2014) was collected from meteorological observatory located at ICAR-IISWC, RC, Agra for the study. These data were scrutinized and annual maximum daily rainfall was selected for the given time series. Hershfield (1965) technique has been used to estimate the probable maximum precipitation. The Gumbel's (1958) distribution was used to determine maximum daily rainfall for return period viz 2, 5,10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90 and 100 years for the this region. These data of maximum rainfall of one-day duration were fitted with regression model and found the coefficient of determination (R^2) for predicting expected probable maximum precipitation of the study area for different return periods for planning and designing soil and water conservation structures.

The results revealed that the recorded one day maximum rainfall was 322.0 mm in 1981 and minimum rainfall was 42.4mm in 2001. It is inferred that there could be wide variations in annual daily maximum rainfall for the different years.

The statistical parameters like average, standard deviation and coefficient of variation were computed for the series of observed one-day maximum rainfall for the period of 1965-2014. The highest observed rainfall (HOR) was also found out for the data series to calculate the ratio of PMP and HOR. The characteristics of annual maximum rainfall of one-day duration are given in Table 1. The average annual maximum rainfall of one-day duration for the region was 89.2mm with standard deviation 47.4mm and 0.53 coefficient of variation. The value of frequency factor was found to be 7.02 for one day duration. It has been estimated and found that PMP for one-day duration over the region was 422.1mm and ratio of PMP to HOR was 1.31. The results are in conformity to the norms laid by WMO (1986).

Table 1 : Rainfall characteristics and PMP (1965-2014)

S. No.	Parameters	Computed values
1	Average one day maximum rainfall (mm)	89.2
2	Standard deviation (mm)	47.4
3	Coefficient of variation	0.531
4	Highest Observed Rainfall (mm)	322.0
5	Probable Maximum Precipitation (mm)	422.1
6	Frequency factor	7.02
7	Ratio, PMP/HOR	1.31

Table 2 : Expected PMP for one day duration for different return period

S. No.	Return period (years)	Expected PMP for one day duration (mm)
1	2	220.6
2	5	273.2
3	10	313.1
4	15	336.4
5	20	352.9
6	25	365.7
7	30	376.2
8	40	392.7
9	50	405.5
10	60	416.0
11	70	424.9
12	80	432.5
13	90	439.3
14	100	445.4

Gumbal's method (1958) has been used to estimate one-day maximum rainfall for different return period viz 2 year, 5 year, 10 year .....100 year for the study area. These data were fitted with trend line for developing regression model. It was found that logarithmic line gave better coefficient of determination ($R^2 = 0.988$) as per the equation:

$Y = 57.46 \ln (X) + 180.8$

Where,

Y= annual maximum rainfall for one-day duration in mm,

X = return period, Years

Using above developed regression model, the PMP's of one day duration was predicted for different return period for same region and using same data series. The predicted values of PMP's are given in Table 2. It is evident from the table that a daily maximum rainfall of 220.6 mm is expected to occur at every 2 years interval. The daily maximum rainfall for 100 years return period was found to be 445.4mm, which is very close to PMP (422.1 mm) found out using Hershfield (1965) model.

Table 3 : The PMP's for design of different soil and water conservation structures

S. No.	Types of soil and water conservation structures	Return period (Year)	PMP (mm)
1	Field bunding / terrace outlets and vegetative waterways	5-10	273.2-313.1
2	Field diversions	15	336.4
3	Small permanent masonry gully control structures	10-15	313.1-336.4
4	Check dams, Drainage Line Treatment(DLT) structures	25	365.7
5	Earthen storage dam with natural spillways	25-50	365.7-405.5
6	Storage and diversion dams having spillways	50-100	405.5-445.4

The different return periods are used in the design of various soil and water conservation structures (Samra *et. al.* 2002). The expected PMP are considered at the time of design of structures. Accordingly, PMP of various hydrological structures were calculated and given in Table 3. It can be seen from the table that expected PMP for structures like terrace outlet, vegetative waterways, field diversion and small permanent gully control structures was found to be between 313.1 to 336.4mm. The expected PMP for other permanent structures like check dam, storage structure with spillways was found to be between 365.7 to 405.5mm.

These computed PMP's can be used to design small and medium hydraulic and soil and water conservation structures. This study could also be useful in developing crop planning strategies in the semi-arid region of central India.

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