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Heaviest rainfall ever recorded in relation to its return period

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ABSTRACT. For hydrological design purposes, it is not sufficient to take into account only the heaviest rainfall recorded at the place. Instead, the return period of the heaviest rainfall recorded and also the extreme values of rainfall for different return periods should be taken into account. The return period and the probability of occurrence of the heaviest rainfall recorded at selected observatory stations in India have been computed and presented.

1. Introduction

Figures of the heaviest rainfall ever recorded constitute an important information given in *Climatological Tables of Observatories*. These are no doubt useful. A climatological chart usually prepared is the one showing isopleths of the heaviest rainfall ever recorded. In the preparation of such a map, figures of the heaviest rainfall ever recorded at a large number of stations are plotted and isopleths drawn. In doing so, there appears to be a tacit assumption that the extreme rainfall recorded at one station has the same probability of occurrence as that at another station. This need not be so and therefore any comparative estimates made on the basis of such a chart are liable to be unreliable.

For the design of such structures as bridges, spill ways, culverts, storm sewers or airfield drainage, it is often necessary to determine the maximum rainfall that may be expected to occur in the concerned basin. As these basins are small, point rainfall is generally taken into consideration. Engineers sometimes find out the heaviest rainfall recorded at a particular location and consider it for design purposes.

In the present note an attempt has been made to show that in using the heaviest rainfall ever recorded, one has to bear in mind its probability of occurrence apart from its magnitude and that comparing the heaviest rainfall recorded at one station with that at another without taking into account the probabilities of the two is not advisable for practical planning. More reliance should be placed on frequency studies.

2. Data and method

For this study daily rainfall values for about 50 I.M.D. observatories distributed over the country were considered. The annual series of maximum rainfall in 24 hrs for about 50 years for each of the stations, were subjected to frequency analysis using Gumbel's (1954) extreme value technique. The heaviest rainfall in 24 hrs recorded at a particular station, as given in the *Climatological Tables of Observatories in India* (*1931-1960*), was picked up and its return period value was calculated by including this heaviest amount in the series and also after excluding it from the series. The probability of occurrence of the heaviest rainfall, in any year, was calculated from its return period. As return period, a statistical parameter used in frequency analysis, is a measure of the probable time interval between the occurrence of a given event and that of an equal or greater event, it can easily be used to calculate the required probability. If $\phi(x)$ is the probability of occurrence of an event of magnitude x, its return period (T) can be written as—

$$T = 1/\phi(x)$$

Since T is the time interval in which the event of magnitude x occurs once, on an average, the probability $\phi(x)$ of occurrence of this event, in any year, is $1/T$. Thus the probability is the inverse of return period. From this relation, the probability (in per cent) of occurrence of the heaviest rainfall was calculated from its return period. The results are given in Table 1.

TABLE 1

Station	Heaviest rainfall in 24-hr (mm)	Date	Return period of the heaviest rainfall (yrs)		Probability of occurrence of the rainfall in any year (%)	
			(a)	(b)	(a)	(b)
Dhubri	368·3	11 Jun 1909	172	370	0·581	0·270
Lumding	166·4	29 May 1936	46	60	2·174	1·667
Sibsagar	218·9	18 Jul 1929	71	108	1·408	0·926
Shillong	415·3	28 Jun 1934	172	370	0·581	0·270
Kalimpong	302·0	12 Jun 1950	113	197	0·885	0·508
Midnapore	325·1	17 Oct 1942	260	713	0·385	0·140
Angul	257·3	21 Aug 1931	84	131	1·190	0·763
Balasore	347·2	1 Jul 1940	472	1787	0·212	0.056
Puri	316·2	3 Oct 1928	105	193	0·952	0·518
Chaibasa	214·6	2 Oct 1914	36	45	2·778	2·222
Darbhanga	266·7	4 Sep 1925	43	57	2·325	1·754
Dhanbad	272·0	8 Aug 1913	133	295	0·752	0·339
Gaya	258·6	10 Aug 1942	112	201	0·893	0·498
Motihari	254·8	3 Jul 1935	39	51	2·564	1·961
Ranchi	231·1	19 Oct 1941	177	410	0·565	0·244
Lucknow	311·7	17 Jul 1947	610	2605	0·164	0·038
New Delhi	266·2	21 Jul 1956	70	115	1·429	0·870
Simla	227·1	22 Aug 1901	122	233	0·820	0·429
Srinagar	147·8	31 Jan 1930	650	3881	0·154	0·026
Jaipur	188·4	16 Aug 1959	43	58	2·325	1·724
Mount Abu	484·9	14 Aug 1941	29	36	3·448	2·778
Jagdalpur	203·2	15 Aug 1931	36	47	2·778	2·128
Jabalpur	342·9	30 Jul 1915	111	200	0·900	0·500
Khandwa	240·5	13 Jul 1927	77	129	1·299	0·775
Pendra Road	262·1	18 Aug 1953	77	120	1·299	0·833
Pachmarhi	458·7	2 Aug 1913	147	342	0·680	0·292

(a) Including the heaviest rainfall in the series

(b) Excluding the heaviest rainfall from the series

TABLE 1 (*contd*)

Station	Heaviest rainfall in 24-hr (mm)	Date	Return period of the heaviest rainfall (yrs)		Probability of occurrence of the rainfall in any year (%)	
			(a)	(b)	(a)	(b)
Sagar	284·5	10 Jul 1904	59	83	1·695	1·205
Seoni	281·9	2 Aug 1913	39	49	2·564	2·041
Surat	459·2	2 Jul 1941	85	138	1·176	0·725
Veraval	289·6	16 Jul 1945	31	39	3·226	2·564
Amraoti	234·9	15 Sep 1933	105	174	0·952	0·575
Bombay	548·1	10 Sep 1930	386	1549	0·259	0·065
Jalgaon	182·9	13 Sep 1930	95	153	1·053	0·654
Nagpur	315·0	12 Jun 1911	548	2305	0·182	0·043
Sholapur	191·0	12 Aug 1940	114	206	0·877	0·485
Sironcha	247·4	14 Aug 1953	170	341	0·588	0·293
Begumpet	190·5	1 Aug 1954	285	939	0·351	0·106
Kakinada	501·3	2 Jun 1941	1060	7783	0·094	0·013
Kalingapatnam	310·6	24 Sep 1911	139	259	0·719	0·386
Masulipatnam	502·4	28 Oct 1949	710	3637	0·141	0·027
Ongole	258·3	17 Nov 1946	61	87	1·639	1·149
Kodaikanal	346·2	16 Nov 1935	2883	84912	0·035	0·001
Madras	261·6	10 Dec 1901	33	41	3·030	2·439
Madurai	188·0	8 Feb 1929	72	119	1·389	0·840
Palayamkottai	202·7	10 Nov 1933	289	894	0·346	0·112
Vellore	299·0	30 Nov 1930	270	775	0·370	0·129
Bijapur	143·8	22 Sep 1949	92	172	1·087	0·581
Honavar	378·5	5 Jun 1919	190	447	0·526	0·224
Mangalore	360·9	8 May 1909	422	1755	0·237	0·057
Mercara	364·5	17 Jul 1924	200	493	0·500	0·203
Cochin	253·2	28 May 1933	157	334	0·637	0·299
Kozhikode	263·5	25 May 1932	21	24	4·762	4·167

(a) Including the heaviest rainfall in the series

(b) Excluding the heaviest rainfall from the series

3. Results

It can be seen from Table 1 that the return period values for the heaviest rainfall recorded at different stations vary from 21 years to 2883 years when the heaviest rainfall is included in the series and from 24 years to 84912 years when the heaviest rainfall is not included in the series. In either case the return periods are not only widely different from each other but they are also different from generally estimated values equal to the number of years of data considered. The probabilities of occurrence of the heaviest rainfall amounts at different stations, in any year, are also seen to differ widely from each other. Hence for design purposes, it is not advisable to take into account only the heaviest rainfall recorded at a particular station. Its return period and also the extreme values of rainfall for different return periods should be taken into account to know the average number of years within which a given amount of rainfall is equalled or exceeded.

It may be mentioned in this connection that the return period of a given event (*e.g.*, 24 hours rainfall) is the average number of years within which the event will be equalled or exceeded. It should be noted that the concepts of the return period and N-year event contain no implication that an event of any given magnitude will occur at constant or even approximately constant intervals of N-years. Both the terms refer to the expected, average frequency of occurrence of an event over a long period of years. This is what is required by engineers for design purposes.

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