SHOULD EXTREME PRECIPITATION RECORDED OVER A LONG PERIOD OF TIME BE CONSIDERED AS AN ESTIMATE OF PMP?

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Abstract: The World Meteorological Organization's Manual (1986) has given very elaborate procedures for the estimation of Probable Maximum Precipitation for the design of hydraulic structures where no risks can be taken. These are based upon the assumption that severe meteorological factors like rainstorm mechanism and extreme moisture charge, which when combined together will produce PMP. McGregor (1998) and others feel that in nature, extreme meteorological factors may never combine, as such PMP depths obtained by the above procedures are only hypothetical. It has been suggested that actual extreme values of precipitation obtained over the globe based upon a long period of data may be considered as PMP. In view of this, extreme values of precipitation obtained over India during the last 125 years have been picked out from the data and their values for point stations as well as for different standard areas and durations (i.e. Depth-Area-Duration (DAD) statistics) have been given in this paper and may be considered as estimates of PMP for different regions of the country.

Keywords: Depth-Area-Duration (DAD), India, moisture charge, Probable Maximum Precipitation (PMP), rainstorm mechanism.

INTRODUCTION

The World Meteorological Organization (WMO) has given detailed procedures as developed by the Office of Hydrology, US Weather Bureau, in their Manual of PMP estimation (WMO, 1986). In India, (Dhar, 1992 and Dhar and Nandargi, 1994) have written about the estimation of Probable Maximum Precipitation (PMP) as applied to the long period Indian rainfall data. It appears that the concept of PMP is supported by Gumbel's (1958) remarks that big floods will always be severe and experience has shown that is correct. No doubt, floods normally are caused by heavy rainfall but besides rainfall, there are other factors that cause heightened severity and these are: deforestation, erosion, silting of river beds, encroachment on flood plains, embankments and bridges across the rivers, and so on. On the other hand, Horton (1936) felt that there is an upper limit for such things. A small stream cannot produce a major Mississippi river flood, for much of the same reason that an ordinary barnyard fowl cannot lay an egg a yard in diameter, as it would transcend nature's capabilities.

In view of the above, contradictory statements expressed by experts, state that where precipitation is concerned, there is a broad upper limit for this phenomenon, which depends upon the geographical location of a place (i.e. Latitude), its altitude, distance from the neighbouring seas, orientation with respect to rainstorm tracks, prevailing wind direction, etc.

According to present-day hydrological literature, PMP has been defined as the greatest depth of precipitation over a given place (or area) for a certain duration which can be reached but not exceeded under the meteorological conditions which are present at the time (McGregor *et al.*, 1998).

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According to the WMO Manual (1986), PMP is normally estimated by empirical meteorological relationships such as storm transposition, dewpoint maximisation in order to obtain extreme precipitation for a given place and duration. It has no specific return period, but in India, a 10,000-year value is considered as its return period. According to McGregor *et al.*, (1998), PMP estimates are only hypothetical values which are obtained for a set of extreme meteorological factors, like storm mechanisms and maximum moisture charge, when combined, can produce PMP.

Table 1. Highest recorded point rainfalls (≥ 50 cm) for one-day duration (1875 to 1990).

No.	Station	State	Altitude (m)	Highest point rainfall (cm) for one-day duration
1	Kakinada	Andhra Pradesh	8	50
2	Dharampur	Gujarat	38	99
3	Porbandar	Gujarat	12	51
4	Agumbe	Karnataka	659	62
5	Bhagamandala	Karnataka	876	84
6	Ponnampet	Karnataka	857	52
7	Quilandi	Kerala	8	91
8	Rewa	Madhya Pradesh	286	77
9	Satna	Madhya Pradesh	549	54
10	Bombay	Maharashtra	11	57
11	Karjat	Maharashtra	107	61
12	Khandala	Maharashtra	539	52
13	Vengurla	Maharashtra	9	53
14	Gopalpur	Orissa	17	51
15	Bamanwas	Rajasthan	252	51
16	Bassi	Rajasthan	351	56
17	Cuddalore	Tamil Nadu	12	57
18	Dhampur	Uttar Pradesh	258	77
19	Nagina	Uttar Pradesh	250	82
20	Najibabad	Uttar Pradesh	240	72

However, in reality, the combination of such extreme meteorological factors may never happen in nature. In fact, our present knowledge of rainstorm mechanism which can produce extreme precipitation is imperfect. As such, it has been recently pointed out that since PMP depths are only theoretical estimates, which may never be obtained, it would be preferable to approach the subject on the basis of actual values of the highest or extreme precipitation obtained from a long-period of precipitation records over the globe (McGregor *et al.*, 1998) for obtaining PMP estimates to aid the design of such hydraulic structures where absolutely no risks can be taken.

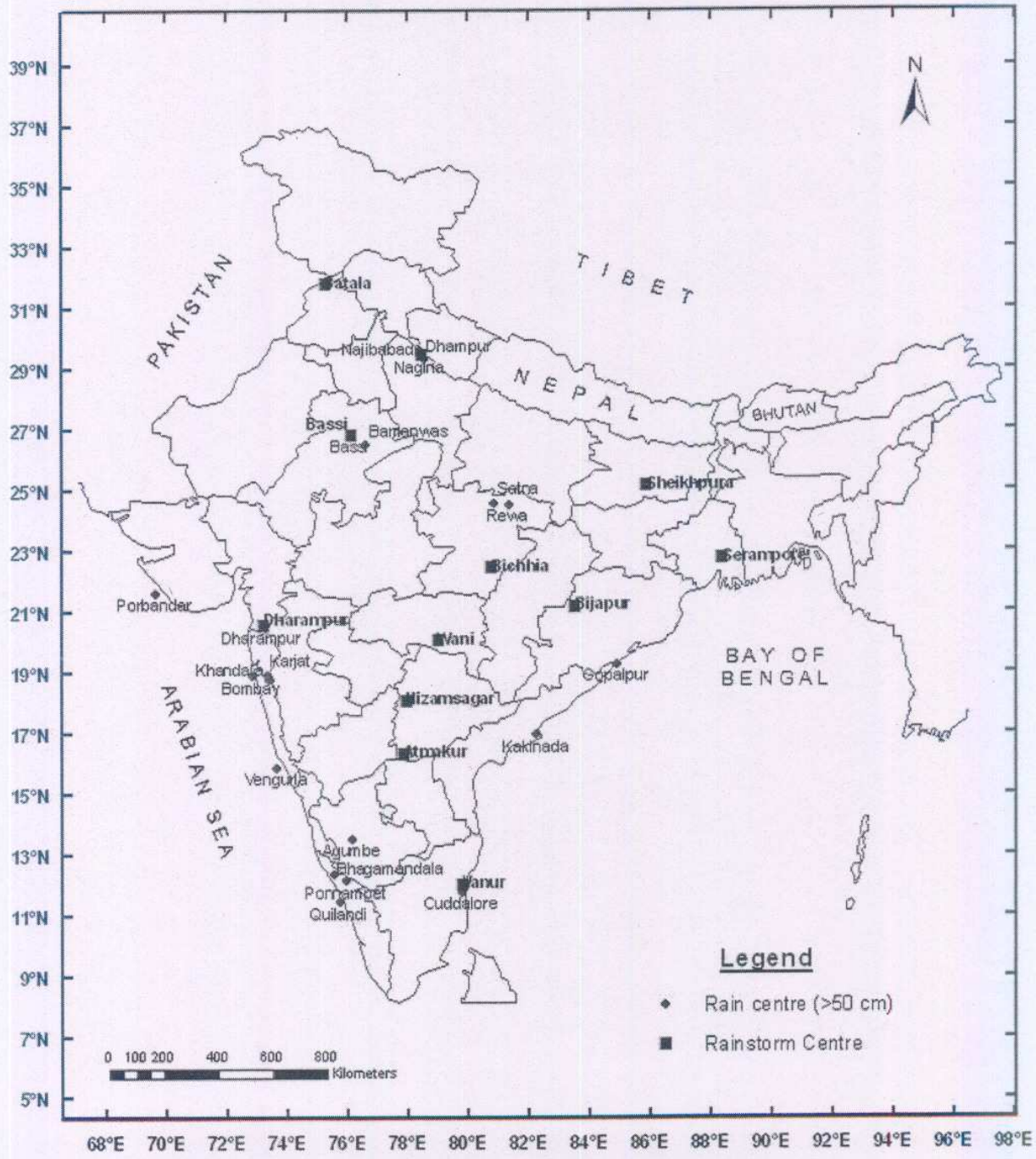

Figure 1. Centre locations of one-day highest rainfall and most severe rainstorms over India.

Table 2. Highest Depth-Area-Duration (DAD) values (cm) of extreme rainstorms over different regions of India (1880 to 1990). *(Continued on page 89).*

No.	Rainstorm date	Storm centre	States	Duration (days)	Area in hundreds of km2					
					Point	1	10	50	100	200
1	17-18 Sept., 1880	Nagina	Uttar Pradesh	1	82	82	78	63	52	40
				2	104	103	99	87	77	62
2	20-22 Sept., 1900	Serampore	West Bengal	1	44	43	41	36	33	28
				2	73	72	67	58	52	44
				3	83	82	78	69	62	52
3	19-21 Sept., 1926	Bichhia	Madhya Pradesh	1	36	36	35	33	30	26
				2	65	65	63	57	53	47
				3	83	82	81	76	71	62
4	1-3 Jul., 1930	Wani	Maharashtra	1	36	36	31	24	22	19
				2	71	70	58	40	33	28
				3	77	76	66	47	39	35
5	1-3 Jul., 1941	Dharampur	Gujarat	1	99	97	85	65	54	43
				2	127	126	118	97	83	66
				3	145	143	134	117	105	86
6	17-19 May, 1943	Vanur	Tamil Nadu	1	42	41	37	29	25	21
				2	72	72	69	55	46	37

7	3-5 Oct., 1955	Batala	Punjab	1	50	47	45	40	35	29
				2	72	70	64	56	51	44
				3	72	71	67	59	53	47
8	1-3 Aug., 1961	Sheikhpura	Bihar	1	37	37	36	32	28	23
				2	55	54	53	49	44	35
				3	58	57	57	54	50	42
9	28-30 Sept., 1964	Atmakur	Karnataka	1	24	23	23	22	21	19
				2	44	43	32	27	25	22
				3	62	61	51	38	34	30
10	13-15 Jul., 1965	Nizamsagar	Andhra Pradesh	1	51	49	39	25	20	16
				2	54	52	41	27	23	20
				3	60	57	45	30	27	23
11	18-20 Jul., 1981	Bassi	Rajasthan	1	56	56	54	45	37	27
				2	84	83	76	62	52	40
				3	97	95	85	71	61	48
12	28-30 Aug., 1982	Bijapur	Orissa	1	52	52	51	45	38	30
				2	70	70	69	65	59	50
				3	88	88	84	74	66	55

Table 2. Continued from Page 88.

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Hershfield (1965) gave a statistical method (Dhar and Nandargi, 1994) for obtaining PMP for point stations using long period precipitation data from the USA. Because of the simplicity of the method, this technique became quite popular with design engineers and hydrometeorologists. In the USA, this method is not regarded as a valid measure of PMP (Hansen, 1987 and 1991). It is generally used by them to get a quick check of the PMP values obtained by traditional methods of storm transposition and dewpoint maximisation and that too for point stations only. The other disadvantage with the statistical method is that it does not provide any information about areal or temporal distribution of PMP. Lin and Vogel (1993) have found that it requires a long-period, at least 150 years or more of precipitation data, in order to obtain a reliable estimate of PMP for a station by the statistical method.

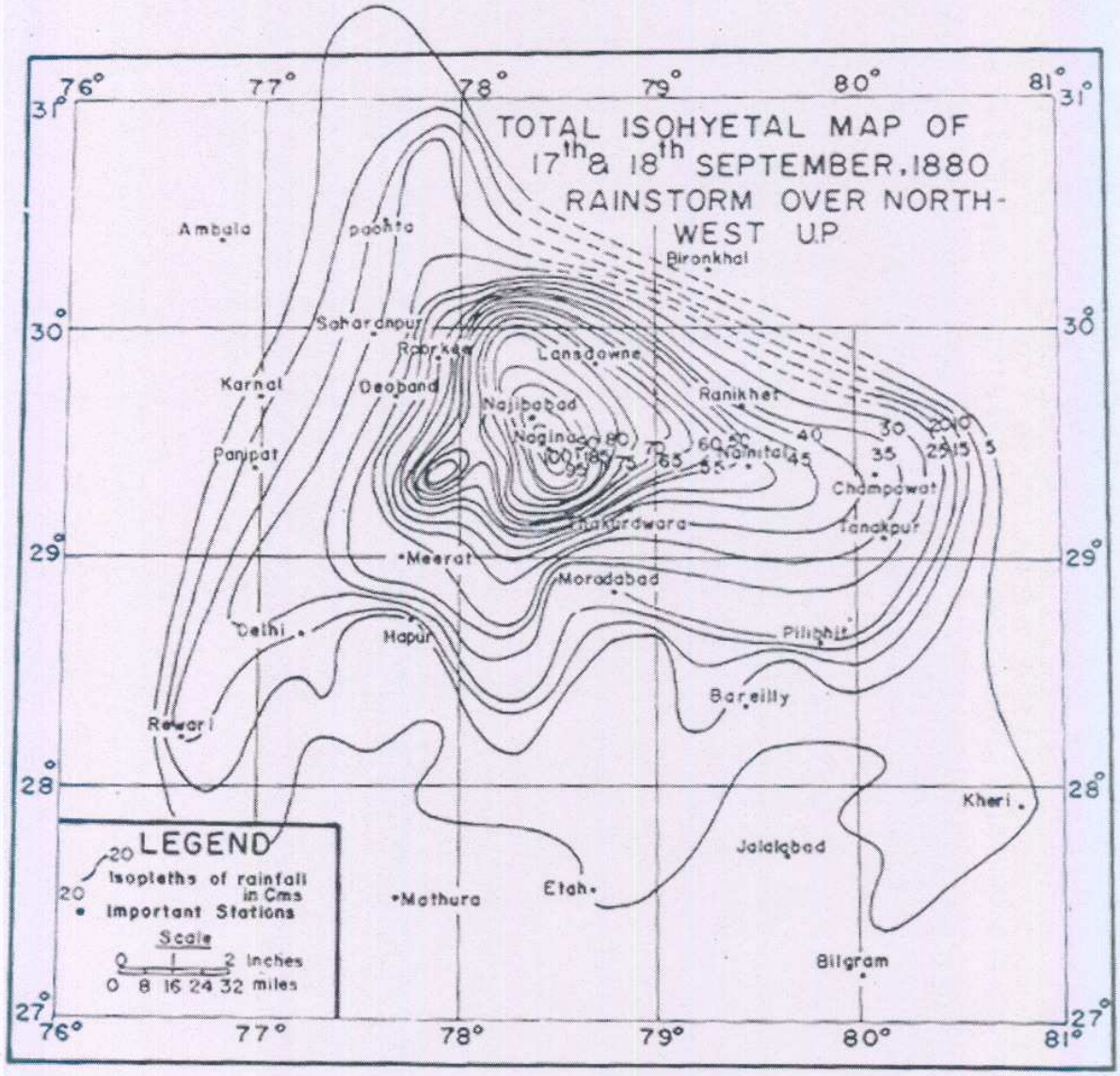

Figure 2. Two-day severe rainstorm of 17-18 September 1880 which occurred over northwest Uttar Pradesh (see Table 2).

In view of the general acceptance that there is an upper limit to precipitation for a given place or an area and for a given duration, the authors are in full agreement with McGregor (1998) that the best way to obtain an estimation of PMP is to use the actual extreme precipitation of a place or region which occurred over a long period of time rather than to obtain it from a set of extreme values of meteorological factors which in reality may never combine to obtain PMP.

India being one of the few tropical countries in the world which has precipitation data continuously available for more than 125 years for a good network of stations. Highest magnitudes of precipitation, both for point as well as different standard areas and durations (DAD values) have been worked out (IITM, 1994; Dhar and Nandargi, 1998). From this data, extreme values of precipitation magnitudes for point as well as for different standard areas have been picked out so as to give an idea of the magnitude of extreme precipitation actually received in different regions of the country. Table 1 gives point precipitation obtained for selected stations in India having recorded precipitation greater than 50 cms during one-day duration over a period of 1875 to1990. Extreme areal precipitation (DAD values) for standard areas obtained from the 12 most severe rainstorms (1880 to 1990) over different regions of India during one, two and three-day durations are also given in Table 2. Figure 1 shows the locations of stations which recorded the highest point rainfall greater than 50 cms in one day as well as centres of most severe rainstorms over the Indian region as given in Table 2. Figure 2 shows the two-day isohyetal pattern of a most severe rainstorm that occurred far inland away from neighbouring seas on 17-18 September 1880 over northwest Uttar Pradesh (Dhar *et al.,* 1975).

It is felt that to obtain PMP depths for any place or an area in India for the design of hydraulic structures where no risks can be taken, one may use these extreme depths of precipitation recorded over a period of more than 125 years, instead of working out theoretical estimates of PMP by storm transposition and moisture charge methods whose occurrence is doubtful.

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