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Some characteristics of rainfall at Poona

K.R. KRISHNASWAMY
Meteorological Office, Poona

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ABSTRACT. The paper gives the results of an analysis of the rainfall recorded in fifteen-minute intervals at Poona from the records of the Casella siphon raingauge during the years 1932-1943. The frequencies of intensities of rain, of the maximum intensities on rainy days and of the hours of occurrence of maximum intensities have been tabulated. The number of spells of rain on rainy days and the intervals between successive spells of rain have also been tabulated.

1. *Introduction.*

In one of the Scientific Notes of the India Meteorological Department, Narasimhan and Md. Zafar[1] have analysed the hourly rainfall at Poona in the period 1930-39. However, no analysis has so far been made of the intensity of rainfall by measuring the rainfall recorded in much shorter intervals of time than one hour. The present paper summarises the analysis of rainfall data in periods of fifteen minutes. An attempt has also been made to study the variation of intensity of rain measured in fifteen-minute intervals in different spells of rain in different seasons, a spell of rain being a period during which rain fell uninterruptedly. For studying erosion effects of rain or floods in towns and river basins, it may be enough if the intensity of rainfall is obtained from the falls in intervals of fifteen minutes.

2. *Description of data and method of analysis.*

The intensities of rainfall were obtained from the records for the period 1932 to 1943 obtained on a daily siphon raingauge installed at the Meteorological Office at Poona. From the rainfall chart one can get the amount of rain that has fallen in any interval of time correct to a cent. But the smallest period of time that can conveniently be read on the chart is 15 minutes. It is therefore, possible to find from the charts the amount of rain falling in successive intervals of 15 minutes and hence to work out the average intensities per hour during those intervals. It is also possible to study the variation of the intensity of rainfall in all the spells of rain during the year.

3. *Spells of rain at Poona.*

The number of rainy days in each month and the associated number of spells of rain are given in Table 1 below. A rainy day has been taken as a period of 24 hours commencing at 00 hours I.S.T. during which one cent or more rain was recorded. The

TABLE 1.

Total and average number of rainy days and of spells of rain during the period 1932 to 1943.

Month	Number of rainy days.	Average number of rainy days in month.	Number of spells of rain.	Average number of spells of rain in the month	Average number of spells per rainy day.
January	5	0.4	8	0.7	2
February	2	0.2	3	0.3	2
March	5	0.4	7	0.6	1
April	27	2.3	36	3.0	1
May	43	3.6	96	8.0	2
June	177	14.7	542	45.2	3
July	313	26.1	1495	124.6	5
August	251	20.9	859	71.6	3
September	156	13.0	435	36.3	3
October	98	8.2	210	17.5	2
November	25	2.1	61	5.1	2
December	8	0.7	16	1.3	2

frequency distribution of the number of spells on a rainy day in the different months is given in Table 2. It appears from these tables that the number of spells of rain generally increases with the increase in the number of days. In the months January to April, rainfall generally occurs as a single spell. In the monsoon months rainfall generally occurs in a number of spells, the days with single spell being about 30 per cent in June, August and September. In July, the month of maximum rainfall of the year, the single spell days decrease to 11 per cent and the majority of rainy days have four or more spells of rain. In the remaining months of the year the majority have one to three spells of rain.

The frequency distribution of spells of rain according to their durations is shown in Table 3 and Table 4 gives the interval of time between consecutive spells of rain. It is interesting to note that the distributions of the number of spells of rain are similar in the mid-monsoon months July and August and in the months on either side of these *viz.*, June and September and May and October, and to a smaller extent in April and November. It may also be noted from Table 4 that the distribution of the time interval between the spells of rain are also similar in these pairs of months except in April and November. It, therefore, appears that the factors controlling the number of spells of different durations are similar in these corresponding months on either side of the period of highest monsoon activity *viz.*, July and August. This probably represents the characteristic feature of the particular region of the monsoon current which is observed both during its northward movement during the onset and its southward movement during its withdrawal. It is most likely that this feature must have a relation to the upper air conditions over Poona during these months.

The rainfall in November and December can be associated with the passage of cyclones originating in the Bay or in the Arabian Sea and passing near enough to affect the weather at Poona; this is, however, not a feature occurring every year.

4. *Intensity of rainfall.*

Table 5 shows the frequencies of different intensities recorded in fifteen minute intervals in cents per hour and Table 6 shows the frequency of maximum intensities of rainfall recorded on rainy days. It is interesting to note from these tables that rainfall intensities exceeding 1" per hour occur generally in the months of May and June or in the months of September and October. Rainfall intensities exceeding two inches per hour have occurred only during these months during the period 1932 to 1943. During these months the rainfall at Poona is mostly associated with thunderstorms.

The number of occasions when rainfall exceeding two inches per hour occurs is greater in the post-monsoon months than in the pre-monsoon months. One can expect this occurrence as the retreating monsoon front remains over these regions during these months. There is also greater moisture in the atmosphere during these months due to the preceding long spell of monsoon, while during May and June the rainfall is associated with the onset of the monsoon and the movement of the front is faster.

The following interesting observations are also possible from the two Tables 5 and 6:

(i) The most frequent intensity of rainfall is less than 10 cents per hour in all the months of the year. This can be due to the fact that such intensities generally occur in the beginning and the end of every spell of rain.

(ii) During the monsoon months June to September, more than 75 per cent of the period of rainfall is in the form of drizzle and with an intensity less than ten cents per hour.

(iii) It is also observed that the maximum intensity of rain on a rainy day during these months is mostly less than 25 cents per hour. This shows the chief characteristics of the rainfall at Poona during the monsoon.

5. *Diurnal variation of intensity of rainfall.*

Table 7 shows the hours of occurrence of maximum intensities of rainfall. For this purpose the maximum intensity on each rainy day was noted and also the number of fifteen-minute intervals and the hours of the day in which these intervals fall. On most days the maximum intensity is attained only once, but on quite a number of days, particularly in the months of July and August, the same intensity was recorded in more than one interval. Thus the totals indicated in this

TABLE 2.

Total number of rainy days with different numbers of spells of rain, 1932 to 1943.

Month	Number of rainy days.	Number of spells of rain.										
		1	2	3	4	5	6	7	8	9	10	10–
January	5	4(80)	..	..	1(20)	..	..	..	..	..	..	..
February	2	1(50)	1(50)	..	..	..	..	..	..	..	..	..
March	5	4(80)	..	1(20)	..	..	..	..	..	..	..	..
April	27	19(70)	7(26)	..	1(4)	..	..	..	..	..	..	..
May	43	18(41)	12(28)	5(12)	2(5)	5(12)	1(2)	..	..	..	..	..
June	177	59(33)	38(21)	27(15)	15(8)	9(5)	8(4)	10(6)	3(2)	4(2)	2(1)	2(1)
July	313	35(11)	51(16)	54(17)	39(12)	33(10)	29(9)	28(9)	7(2)	14(4)	10(3)	13(4)
August	251	73(29)	44(18)	45(18)	27(11)	17(7)	18(7)	7(3)	8(3)	7(3)	4(2)	1(–)
September	156	49(31)	34(22)	34(22)	17(11)	10(6)	2(1)	3(2)	3(2)	2(1)	2(1)	..
October	98	47(48)	25(26)	12(12)	7(7)	1(1)	4(4)	..	1(1)	1(1)	..	..
November	25	13(52)	4(16)	1(4)	5(20)	1(4)	1(4)	..	..	..	..	..
December	8	4(50)	1(13)	2(25)	1(13)	..	..	..	..	..	..	..

(The percentage frequency of spells is shown in brackets).

TABLE 3.

Numbers of spells of rainfall of various durations, 1932 to 1943.

Month.	Number of spells of rain.	Duration in hours.												
		–½	½–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–
January ..	8	4(50)	1(12)	1(12)	..	2(24)	..	..	..	..	..	..	..	..	..
February ..	3	1(33)	1(33)	1(33)	..	..	..	..	..	..	..	..	..	..	..
March ..	7	4(57)	2(29)	1(14)	..	..	..	..	..	..	..	..	..	..	..
April ..	36	19(53)	8(22)	6(17)	3(8)	..	..	..	..	..	..	..	..	..	..
May ..	96	52(54)	19(20)	17(18)	2(2)	2(2)	3(3)	..	1(1)	..	..	..	..	..	..
June ..	542	276(51)	108(20)	72(13)	35(6)	22(4)	13(2)	7(1)	1(–)	2(–)	3(1)	2(–)	..	..	1(–)
July ..	1495	929(62)	256(17)	168(11)	62(4)	31(2)	14(1)	6(–)	8(1)	5(–)	5(–)	2(–)	..	3(–)	6(–)
August ..	859	521(62)	160(18)	98(11)	23(3)	25(2)	13(1)	5(1)	2(–)	5(1)	..	1(–)	2(–)	..	4(1)
September ..	435	211(48)	105(24)	64(15)	22(5)	15(3)	5(1)	3(1)	3(1)	2(–)	2(–)	..	2(–)	..	1(–)
October ..	210	93(44)	50(24)	33(16)	13(6)	8(4)	5(2)	2(1)	2(1)	1(–)	2(1)	..	..	..	1(–)
November ..	61	32(52)	14(23)	10(16)	1(2)	2(3)	..	1(2)	..	..	..	..	..	..	1(2)
December ..	16	6(38)	4(25)	3(19)	..	3(19)	..	..	..	..	..	..	..	..	..

(The figures indicated in the brackets are percentage frequencies).

TABLE 4.

Intervals between consecutive spells of rain, 1932 to 1943

Month	Intervals in hours.													
	–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–24	24–
January	1 (20)	2 (40)	..	..	..	..	..	..	..	..	..	..	1 (20)	..
February	..	1 (100)	..	..	..	..	..	..	..	..	..	..	..	..
March	1 (25)	..	..	..	..	..	..	..	..	..	..	..	1 (25)	2 (50)
April	6 (22)	1 (4)	2 (7)	..	..	..	..	1 (4)	..	..	..	..	2 (7)	15 (56)
May	21 (24)	14 (16)	4 (5)	5 (6)	4 (5)	3 (3)	2 (2)	1 (1)	3 (3)	2 (2)	1 (1)	(1)	14 (16)	12 (14)
June	149 (28)	80 (15)	55 (10)	33 (6)	19 (4)	20 (4)	14 (3)	10 (2)	13 (2)	10 (2)	9 (2)	5 (1)	52 (10)	60 (11)
July	429 (29)	324 (22)	181 (12)	91 (6)	75 (5)	62 (4)	55 (4)	40 (3)	28 (2)	28 (2)	14 (1)	15 (1)	84 (6)	47 (3)
August	172 (20)	170 (20)	87 (10)	59 (7)	52 (6)	32 (4)	31 (4)	18 (2)	20 (2)	14 (2)	11 (1)	20 (2)	92 (11)	68 (8)
September	86 (20)	61 (14)	48 (11)	28 (7)	16 (4)	10 (2)	13 (3)	13 (3)	10 (2)	9 (2)	9 (2)	6 (1)	52 (12)	63 (15)
October	38 (19)	22 (11)	16 (8)	19 (10)	8 (4)	7 (4)	5 (3)	4 (2)	2 (1)	4 (2)	4 (2)	2 (1)	32 (16)	35 (18)
November	22 (42)	9 (17)	4 (8)	3 (6)	1 (2)	..	..	..	1 (2)	..	..	..	3 (6)	9 (17)
December	3 (27)	3 (27)	1 (9)	..	1 (9)	..	..	..	..	..	..	..	1 (9)	2 (18)

TABLE 5.

Number of fifteen-minute intervals in which different intensities of rain were recorded—1932 to 1943.

Month.	Intensity (Cents per hour).							
	–10	10–25	25–50	50–75	75–100	100–200	200–300	300–
January	36(*95*)	2(*5*)	—	—	—	—	—	—
February	15(*8*)	1(*6*)	1(*6*)	—	—	—	—	—
March	18(*90*)	—	1(*5*)	1(*5*)	—	—	—	—
April	66(*57*)	25(*22*)	12(*10*)	1(*1*)	5(*4*)	7(*6*)	—	—
May	252(*73*)	47(*14*)	23(*7*)	5(*1*)	3(*1*)	13(*4*)	1(–)	2(*1*)
June	1932(*77*)	401(*16*)	109(*4*)	35(*1*)	15(*1*)	18(*1*)	4(–)	2(–)
July	4532(*83*)	681(*12*)	181(*3*)	41(*1*)	14(–)	5(–)	—	—
August	2671(*89*)	272(*9*)	44(*1*)	7(–)	3(–)	7(–)	—	—
September	1413(*74*)	291(*15*)	103(*5*)	35(*2*)	24(*2*)	32(*2*)	6(–)	7(–)
October	757(*69*)	195(*17*)	67(*6*)	35(*3*)	15(*2*)	25(*2*)	7(*1*)	2(–)
November	212(*69*)	55(*18*)	20(*6*)	10(*3*)	5(*2*)	6(*2*)	—	—
December	61(*74*)	8(*10*)	9(*11*)	1(*1*)	1(*1*)	1(*1*)	1(*1*)	—

(The figures indicated in the brackets are percentage frequencies).

TABLE 6.

Maximum intensities of rainfall on rainy days, 1932 to 1943.

Maximum intensity (cents per hour).	Number of rainy days in											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
— 10	3(*60*)	1(*50*)	4(*80*)	8(*30*)	12(*27*)	65(*37*)	124(*40*)	164(*66*)	59(*38*)	18(*18*)	8(*32*)	2(*25*)
10— 25	2(*40*)	—	—	8(*30*)	11(*25*)	50(*28*)	116(*37*)	54(*22*)	37(*24*)	23(*23*)	3(*12*)	1(*3*)
25— 50	—	1(*50*)	—	4(*15*)	4(*9*)	20(*11*)	48(*15*)	23(*9*)	19(*12*)	12(*12*)	6(*24*)	3(*38*)
50— 75	—	—	1(*20*)	—	3(*7*)	19(*11*)	14(*4*)	3(*1*)	10(*6*)	16(*16*)	2(*8*)	1(*13*)
75—100	—	—	—	3(*11*)	2(*5*)	8(*4*)	6(*2*)	2(*1*)	7(*4*)	7(*7*)	3(*12*)	—
100—200	—	—	—	4(*15*)	9(*21*)	10(*6*)	5(*2*)	5(*2*)	14(*9*)	15(*15*)	3(*12*)	1(*13*)
200—300	—	—	—	—	1(*2*)	3(*1*)	—	—	3(*2*)	5(*5*)	—	—
300—	—	—	—	—	1(*2*)	2(*1*)	—	—	6(*4*)	2(*2*)	—	—

(The figures indicated in the brackets are percentage frequencies).

TABLE 7.

Hours of occurrence of maximum intensity of rainfall on rainy days, 1932 to 1943.

Hour of occurrence.	Number of fifteen-minute intervals in											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0— 3	—	—	—	2(*6*)	7(*13*)	29(*13*)	57(*13*)	60(*14*)	29(*13*)	22(*19*)	6(*22*)	1(*10*)
3— 6	1(*17*)	—	1(*17*)	1(*3*)	1(*2*)	24(*11*)	68(*16*)	81(*19*)	18(*8*)	4(*3*)	—	1(*10*)
6— 9	3(*50*)	—	—	3(*10*)	4(*7*)	27(*12*)	50(*12*)	53(*13*)	14(*6*)	7(*6*)	—	1(*10*)
9—12	—	—	—	—	2(*4*)	24(*11*)	56(*13*)	41(*10*)	19(*8*)	5(*4*)	—	1(*10*)
12—15	—	—	—	5(*16*)	3(5)	38(*17*)	68(*16*)	54(*13*)	29(*13*)	11(*9*)	3(*11*)	—
15—18	2(33)	—	3(*50*)	15(*48*)	18(*32*)	35(*16*)	59(*14*)	50(*12*)	40(*18*)	32(*28*)	5(*18*)	—
18—21	—	2(*100*)	2(*33*)	3(*10*)	15(*27*)	20(*9*)	36(*8*)	40(*10*)	39(*17*)	19(*16*)	9(*32*)	2(*20*)
21—24	—	—	—	2(*6*)	5(*9*)	23(*10*)	41(*9*)	39(*9*)	37(*16*)	16(*14*)	5(*18*)	4(*40*)

(The figures indicated in the brackets are percentage freqencies).

table will not agree with the total number of rainy days given in Table 1.

It appears from Table 7 that the heaviest rainfall of the day occurs in the period 1200 to 2100 in the months February to May and in the period 1200 to 2400 in the post-monsoon months October to December, as well as in September. In the monsoon months June to August, however, the chances of occurrence of the heaviest rainfall of the day are least in the first half of the night *i.e.*, 1800 to 2400 and are more or less the same in the other quarters of the day.

Curves showing the distribution of the intensity of rain on a rainy day in each of the months April to October are also shown in the appended charts (Fig.1). The curves for April, May, June, September and October are typical and are what one would expect when rain is associated with thunderstorms. The curves for July and August show the frequent drizzle type of rain experienced during these months.

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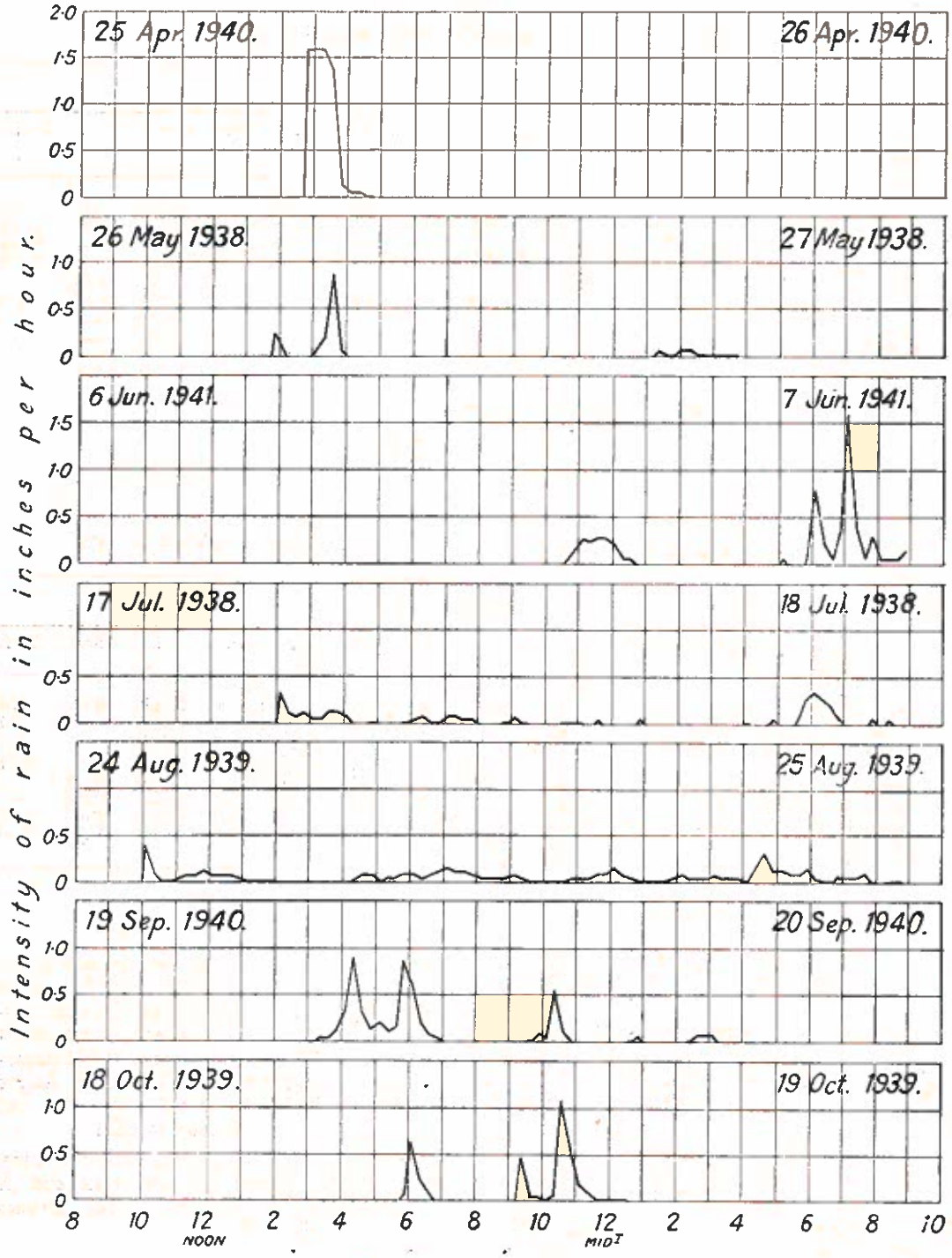

Fig. 1. Curves showing diurnal variation of intensity of rain.