551.577.31 (540)

Diurnal variation of rainfall in India

B. PRASAD

Meteorological Office, Poona

(*Received 25 November 1968*)

ABSTRACT. The mean hourly rainfall for 15 selected stations having the data for the period 1948-1965 has been studied to find out the diurnal variation of rainfall in India. An attempt has been made to explain the different patterns observed on the basis of the models given by the previous workers.

1. Introduction

The diurnal variation of rainfall for the country has been studied by Rao and Raman (1958). But this study was mainly based on data from 0830 to 1730 hours and from 1730 to 0830 hours. A few studies have also been made of individual stations, *e.g.*, of Mahabaleshwar (Pramanik and Rao 1952), of Hyderabad (Rao 1960) and of Nagpur (Mulky 1958). The need for a more detailed and extended study has been felt for a long time. The tabulation of hourly rainfall in a systematic manner was started in 1948 and we have now the hourly values for more than 15 years for 23 stations. A study of these hourly data of 15 stations is presented in this paper. A list of these stations is given in Table 1.

2. Data

Mean hourly rainfall values prepared from hourly tabulations of self-recording raingauges for each of the months for some of the fifteen stations are given in Tables 2 to 9. Cherrapunji and Mahabaleshwar had considerable breaks in their records, no records are available for Cherrapunji for 4 years (1961 and 1963 to 1965) while for Mahabaleshwar there had been a break for about two years in various months.

3. Discussion

3.1. *Hill Stations* – Mahabaleshwar (Table 2) has a marked maximum in the afternoon and evening hours in the pre and post monsoon months. In the monsoon months also there is a slight tendency for the maximum to occur in afternoon hours. In July, a small secondary maximum in the early morning hours (2 to 7 hr) is noticeable. The variation in the rainfall of Cherrapunji (Table 3) with maximum in night/morning hours in all the months differs markedly from other hill stations.

A very well marked maximum in the afternoon in all the months is the main feature of the diurnal variation of rainfall for Kodaikanal. More than 50 per cent of the rain occurs during 12-18 hours. The 12 hours from midnight to noon contribute 15 per cent only of the total rainfall.

Highland works as a source of heat after getting heated up by solar radiation, producing in its wake instability in the atmosphere. This will give rise to convective activity in the afternoon hours. Afternoon maximum in the rainfall in the case of Kodaikanal and outside the monsoon months in the case of Mahabaleshwar is in accord with this idea. The sky remains nearly overcast over Mahabaleshwar in the monsoon months which cuts off the direct solar radiation and thus the afternoon maximum is very much diminished. The radiation cooling at the top of the cloud during night causes internal instability in the clouds which produces a morning maximum usually. July has the highest mean cloud; morning maximum more marked than in the other months.

The pattern of hourly rainfall at Cherrapunji is not explained on the basis of the above argument. It seems that the circulation proposed by Bleeker and Andre (1951), *i.e.*, katabatic winds produces low level convergence increasing the convective activity in the night. Radiation cooling at the top of the cloud further accentuates the convective activity. It gives rise to a tendency for maximum rainfall in the night and early morning. However, this view requires further support by study of more stations in the area.

3.2. *Coastal Stations*—Rainfall maximum occurs in the afternoon/evening hours for all the months, March to December at Calcutta. Midnight to early morning maximum is prominent in January and February.

Rainfall at Sagar Island (Table 4) has a maximum in the morning hours and a minimum in the afternoon and evening during monsoon months. A

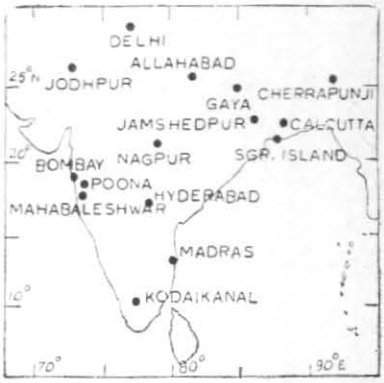

Fig. 1. Map showing the Stations referred to in the text

TABLE 1

	Height (m.a.g.l.)	Lat. (°N)	Long. (°E)	Annual rainfall (mm)
Hill stations				
Cherrapunji	1313	25°15′	91°44′	11418·7
Mahabaleshwar	1382	17 56	73 40	6182·3
Kodaikanal	2343	10 14	77 28	1672·1
Coastal and island stations				
Sagar Island	3	21 45	88 03	1908·4
Calcutta	6	22 39	88 27	1581·8
Bombay	11	18 54	72 49	2099·2
Madras	16	13 00	80 11	1215·3
Inland stations				
Jamshedpur	129	22 49	86 11	1391·3
Gaya	116	24 45	84 57	1096·9
Allahabad	98	25 27	81 44	1027·3
New Delhi	216	28 35	77 12	714·2
Jodhpur	224	21 06	73 01	380·1
Nagpur	310	21 06	79 03	1127·3
Poona	559	18 32	73 51	714·7
Hyderabad	545	17 27	78 28	764·4

These stations are also shown in Fig. 1

pronounced maximum is noticed in the night hours in April while it is not so well marked in May. During the other monsoon months rain is a minimum during afternoon/evening hours.

At Bombay (Table 5) morning maximum is well marked in almost all the months, though it is less in the monsoon months. On the other hand, at Madras (Table 6), higher falls are noted in the late evening and early morning hours in all months except during March and April. Low rainfall during morning hours in southwest monsoon season is an important feature.

Depending upon the prevailing winds the coastal stations will come under oceanic or land influences. When wind blows from land, a station is likely to have afternoon maximum in rainfall, due to the heating of land area. Sea surface is generally warmer than the air above it during night and this helps convective activity. Thus under the oceanic effect, a station should get maximum of rain in the late night and early morning hours.

According to Ramage (1964) sea and land breezes play a significant role in increasing or diminishing rainfall. A breeze opposite to the synoptic wind produces low level convergence and increases the rainfall. Similarly if the breeze is in the same direction as the synoptic wind, rainfall will be reduced. Thus, a west coast station under westerly regime will have early morning maximum as the land breeze will oppose the westerly wind

TABLE 2

CHERRAPUNJI (42514)
Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0·8	2·3	12·4	45·5	96·8	135·0	167·5	128·4	62·7	21·6	2·8	0·1
1—2	0·7	3·2	10·3	42·7	101·4	151·5	149·2	121·8	65·2	21·4	2·7	0·1
2—3	0·8	4·3	15·4	32·2	110·1	165·8	143·1	117·9	65·3	23·7	2·5	0·1
3—4	0·2	3·4	7·1	31·2	112·1	155·8	145·0	109·3	73·5	17·8	3·7	0·6
4—5	0·2	4·4	5·2	34·4	101·1	172·0	204·0	109·4	66·7	18·6	2·6	0·5
5—6	0·3	2·2	6·7	29·6	105·7	156·1	197·7	108·1	63·9	16·5	2·8	0·1
6—7	0·5	0·5	4·4	16·0	91·9	146·7	179.4	89·8	58·3	14·8	2·5	0·1
7—8	1·3	1·1	7·1	14·0	85·6	134·1	166·1	75·9	45·8	15·0	2·7	0
8—9	1·2	0·7	1·2	18·3	66·8	125.2	110·8	62·3	36·5	11·7	1·6	0
9—10	0·9	1·0	6·3	18·3	62·4	136·9	141·1	81·3	42·5	10·0	2·4	0·1
10—11	0·8	0·6	7·5	9·1	51·8	128·2	125·5	72·9	36·9	11·3	3·6	0·3
11—12	1·7	0·3	5·2	8·0	34·8	113·8	100·6	74·3	28·1	9·1	3·3	0
12—13	1·8	0·6	3·2	6·2	30·8	102.9	80·4	55·0	26·7	12·2	2·9	0
13—14	1·8	1·0	4·8	9·6	29·2	73·8	52·0	45·0	17·7	15·9	2·8	0·3
14—15	0·8	1·2	1·1	7·6	36·5	55·1	59·2	38·6	19·7	14·1	1·6	0
15—16	1·4	1·3	1·9	9·8	37·5	62·5	65·3	35·9	14·7	12·8	3·3	0
16—17	0·7	1·3	2·1	8·6	47·0	54·7	36·9	37·6	16·4	8·1	3·1	0·3
17—18	0·7	1·8	2·1	15·6	31·7	57·7	45·9	39·5	14·1	10·7	2·1	0
18—19	0·6	1·8	2·1	32·1	41·0	55·0	56·6	52·6	21·0	12·1	2·9	0·2
19—20	1·2	2·4	7·3	34·0	65·8	77·5	63·1	66·9	21·5	8·8	2·7	0
20—21	0·8	1·1	12·6	43·6	61·2	98·0	87·1	82·5	43·7	9·2	1·9	0
21—22	0·4	2·5	16·3	43·2	107·0	106·3	104·8	79·8	60·6	13·9	2·2	1·3
22—23	1·2	2·1	19·0	59·1	107·7	114·0	121·3	102·7	92·8	17·7	1·9	0
23—24	0	3·0	14·2	43·1	132·5	134·6	152·6	115·1	116·4	17·6	3·1	0·5

TABLE 3

MAHABALESHWAR (43111)
Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0	0	0	1·3	3·1	28·6	99·1	61·3	19·5	4·4	3·3	0·3
1—2	0	0	0	0·7	1·1	30·2	107·4	71·5	17·3	3·4	1·2	0·3
2—3	0	0	0	0·3	1·5	24·5	109·6	67·1	19·3	4·3	0·7	0·2
3—4	0	0	0	0·8	2·8	28·0	109·1	68·9	17·7	3·4	0·9	0·1
4—5	0	0	0	0·2	1·2	26·4	109·9	69·2	16·4	4·5	2·0	0·1
5—6	0	0	0	0·2	1·5	26·0	104·0	63·8	16·5	5·4	1·0	0·4
6—7	0	0	0	0·2	1·2	26·7	106·3	64·7	17·0	3·1	0·5	0·6
7—8	0	0	0	0·1	0·5	26·4	96·7	69·5	19·4	3·9	0·2	1·2
8—9	0	0	0	0	0·6	26·9	81·9	55·2	15·5	4·5	0·6	0·8
9—10	0·1	0	0	0·1	0·1	21·6	98·0	61·8	20·9	3·2	0·6	1·2
10—11	0·3	0	0	0	0·7	23·0	100·7	58·6	17·7	4·3	0·8	0·5
11—12	0	0	0	0	0·4	23·7	92·7	68·8	18·8	3·0	0·5	1·0
12—13	0	0	0	0	0·6	36·2	103·7	76·5	22·5	5·2	0·5	0·7
13—14	0	0	0	0·2	2·7	41·8	107·4	78·4	30·5	7·1	4·1	0·4
14—15	0	0	0	1·1	8·0	49·1	131·0	85·0	33·1	9·0	4·2	0·5
15—16	0·1	0	0·8	3·9	9·0	47·3	119·3	91·9	36·2	14·8	7·1	0·1
16—17	0·3	0	1·7	4·6	8·5	46·5	121·2	90·3	40·3	7·9	3·9	0·3
17—18	0	0	3·6	6·3	9·3	43·3	125·4	84·0	37·1	10·1	3·8	0·3
18—19	0	0	0·1	2·7	6·6	36·0	105·2	76·6	32·5	7·3	3·4	0·1
19—20	0·1	0	0	1·4	3·9	36·0	98·1	74·1	29·4	7·8	7.9	0·1
20—21	0	0	0	0·6	3·5	33·5	96.0	59·6	20·6	7·6	1·5	0·5
21—22	0	0	0	0·5	4·1	27·5	90·3	57·9	17·4	6·3	1·2	0·4
22—23	0	0	0	2·3	2·9	33·0	99·0	59·8	16·6	7·9	1·1	0·4
23—24	0	0	0	0·5	2·3	29·7	107·7	65·8	17·4	3·3	1·0	1·2

TABLE 4

SAGAR ISLAND (42903)
Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0·6	1·1	3·4	1·3	3·1	10·3	13·3	18·9	13·5	6·2	1·0	0·4
1—2	0	1·6	0·8	0·7	3·2	10·4	11·7	21·2	16·8	10·8	1·0	0·2
2—3	0·2	2·2	1·3	0·2	5·4	12·7	15·2	22·1	17.4	8·0	1·1	0·1
3—4	0·9	1·3	1·1	0·5	2·6	14·2✓	18·1	20·0	23·0	10·0	2·1	0
4—5	0	0·2	0·8	0	2·8	11·1	16·4	28·1	25·1✓	8·7	1·8	0·1
5—6	1·1	0·5	0·3	0	2·5	11·5	15·3	23·9	22·5	10·0	1·5	0
6—7	0·6	1·0	0·5	0·1	5·0	9·8	19·6✓	29·6✓	17·2	7·5	0·6	0
7—8	0	0·6	0·2	0·2	3·6	7·0	14·0	17·1	20·0	9·2	1·8	1·6
8—9	0	0·1	0	0·1	4·5	7·8	11·8	12·8	13·8	5·7	2·8	0·8
9—10	0·1	2·0	0	0	4·6	7·1	16·7	20·4	18·5	5·9	1·8	0
10—11	0	0	0	2·3	1·4	8·8	14·3	15·4	17·2	12·2	2·3	0·2
11—12	0·2	0·1	0	0·2	2·4	10·9	12·7	16·0	20·8	12·2	2·7	0
12—13	0·2	0·3	0	0	2·4	11·3	11·2	14·3	20·5	9·1	0·8	0
13—14	0·1	0·7	0·2	0	1·7	7·2	6·3	10·2	12·2	8·3	3·0	0
14—15	0·2	0·2	0·3	0	2·7	5·6	11·2	7·2	18·2	8·9	3·2	0
15—16	0	0·1	0	0·1	1·4	7·9	11·2	7·4	16·1	8·6	2·3	0·8
16—17	0·2	0·6	0·1	1·2	2·2	6·1	8·5	6·0	7·4	5·2	1·6	0·1
17—18	1·1	0·9	1·5	2·0	7·4	3·9✗	8·1	4·8✗	4·8✗	4·8	1·9	0
18—19	0·2	1·7	2·4	2·8	8·5	9·5	4·7	7·5	8·3	2·5	1·9	0
19—20	0·4	2·1	0·3	7·6	5·1	9·2	5·2	8·2	10·1	1·3	1·7	0·1
20—21	0·1	0·8	0·9	3·6	3·4	10·8	3·7✗	8·8	10·6	2·3	1·4	0·4
21—22	0·1	0·6	0	2·4	9·3	7·8	6·4	6·1	14·3	7·7	0·5	0
22—23	0·1	1·2	0	4·6	8·5	9·1	9·9	10·2	9.9	4·7	1·8	0·2
23—24	0·5	1·2	1·9	1·7	1·6	8·1	13·6	12·2	13·3	5·0	0·6	0

TABLE 5

BOMBAY (43057)
Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0	0	0	0·1	0·5	24·1	26·0	21·2	14·8	1·7	1·1	0
1—2	0·1	0·2	0	15·5	0·2	26·1	33·4	24·6	12·6	2·6	0·3	0
2—3	0	0	0	0·5	0·2	22·4	38·3	30·6	14·6	5·1	0·8	0
3—4	0	0	0	0·1	0·3	25·4	39·7	28·4	12·1	7·6	1·9	0·1
4—5	0·3	0	0	0·1	1·0	31·6	32·1	24·4	15·9	8·9	0·6	2·0
5—6	0	0·8	0	0	3·4	29·8	29·7	25·7	17·0	7·4	0·2	0·2
6—7	0	0·1	0·1	0	1·4	35·4✓	37·2	28·8✓	17·4✓	4·9	0·3	0
7—8	0	0	0	0	0·4	25·6	40·4✓	25·3	16·9	3·8	0·3	0·1
8—9	0	0	0	0	0·9	21·3	39·7	21·0	15·0	1·1	0·1	0·1
9—10	0	0	0	0	1·0	20·6	38·0	21·2	17·6	3·2	0·1	0
10—11	0	0	0	0	0	21·6	36·2	27·3	10·2	1·5	0	0
11—12	0	0	0	0	0	21·2	38·9	22·7	8·8	1·1	0·4	0
12—13	0	0	0	0	0	17·5	35·2	19·3	8·3	1·2	0	0
13—14	0	0	0	0	0	17·4	30·8	15·6	11·5	1·2	0·1	0
14—15	0	0	0	0	0	20·8	29·7	16·0	15·3	1·7	0·2	0
15—16	0	0	0	0	0	17·9	30·4	15·9	12·3	1·1	0·2	0
16—17	0	0	0	0	0·1	15·3	27·7	13·1	8·0	0·3	0·4	0
17—18	0	0	0	0	0·5	15·7	22·4✗	10·7✗	8·1	5·0	0·3	0
18—19	0	0	0	0	0·2	13·9✗	25·5	13·4	10·7	5·2	0·3	0
19—20	0	0	0	0·1	0·2	20·9	27·3	15·6	8·1	2·5	0·2	0
20—21	0	0	0	0	0·4	21·1	27·0	16·7	7·4✗	1·6	0	0
21—22	0	0	0	0	0·3	27·1	23·7	17·8	10·7	1·2	0·1	0
22—23	0	0	0	0	1·2	26·8	26·2	13·5	15·9	2·4	0·1	0
23 24	0	0	0	0	0·5	24·3	27·9	16·7	15·5	0·6	1·3	0

TABLE 6

MADRAS (43279)
Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0·5	0·5	0	0	2·4	5·0	4·8	7·7	9.3	18·0	11·8	4·9
1—2	0·8	0·2	0	1·6	1·7	3·6	3·9	8·9	9·4	15·9	16·3	4·1
2—3	0·8	0·3	0	0·1	2·0	3·0	4·4	11·5	8·5	13·4	18·2	5·0
3—4	1·4	0	0	0·2	6·3	3·8	3·6	9·0	7·5	17·7	14·3	6·9
4—5	2·6	0·3	0	1·9	2·4	0·6	2·4	6·2	10·7	10·2	16·6	4·5
5—6	1·2	0	0	0·2	1·5	0·5	2·4	2·6	4·5	11·0	18·3	2·5
6—7	2·0	0	0	0·5	3·0	0·4	1·2	1·6	1·8	6·5	12·7	3·7
7—8	2·0	0	0	0·8	2·7	0·1	1·4	2·2	2·1	6·2	16·1	4·9
8—9	1·9	0	0·1	0·5	2·5	0·1	0·6	2·2	0·3	8·0	10·4	1·8
9—10	1·4	0·3	0·2	1·4	2·3	0	0·8	4·4	0·4	9·1	11·9	4·1
10—11	0·6	0·8	0·4	3·7	1·9	0	0·1	1·1	0·3	7·1	13·4	2·7
11—12	1·2	0·1	0·6	1·6	2·0	0	0·1	0·3	2·5	10·0	9·1	2·8
12—13	2·0	0·1	0·4	1·5	1·0	0·1	0·5	1·2	2·7	13·2	7·7	1·9
13—14	0·7	0	0·1	2·9	1·3	0·2	1·3	2·4	1·0	11·1	7·2	4·0
14—15	1·0	0·4	0	1·2	1·6	0·2	1·1	2·1	3·8	7·3	5·9	2·5
15—16	0·2	0	0	0·1	1·2	0·6	2·9	3·7	3·6	11·6	4·1	3·8
16—17	1·2	0	0·1	0·2	3·0	4·1	3·5	5·6	7·5	6·6	8·6	5·1
17—18	0·7	0·1	0	0	2·1	3·6	12·1	8·7	3·8	7·2	7·8	4·3
18—19	0·5	0·5	0	0·4	2·6	6·1	9·3	12·9	4·8	4·7	9·9	2·0
19—20	0·5	0·4	0	0·1	1·3	8·5	6·5	8.8	3·5	6·3	9·3	3·7
20—21	2·2	0	0·7	0	2·7	7·5	8.8	8·6	7·9	4·9	8·5	2·3
21—22	1·7	0	0	0	2·8	5·0	8·4	9·4	6·2	7·7	11·7	4·1
22—23	1·0	0	0·1	0·1	2·2	4·1	12·0	9·8	6·0	17·0	11·2	3·7
23—24	0·5	0·2	0	0·5	3·1	3·8	7·9	10·6	10·5	8·5	16·7	3·2

under easterly regime when the sea breeze will oppose easterly wind it will have an afternoon/evening maximum. A west coast station should thus have a well marked afternoon or morning maximum. An east coast station will have early morning maximum in the easterly regime and afternoon/evening maximum otherwise. If the synoptic wind is calm the maximum in rainfall is expected in mid-day/early afternoon or in the mid-night/early morning according as the season is summer or winter (predominance of sea or land breeze).

Sagar Island, Bombay and Madras, in general, fit in this model. Calcutta does not behave like a coastal station. It is really farther inland from the coast.

3·3. *Inland Stations*—Jamshedpur (Table 7) and Gaya have maximum rainfall in the afternoon/evening hours throughout the year. Hours of maximum vary from late evening/night in the winter to the afternoon/evening in the monsoon months. A minimum at 10 hours in all the months is another important feature.

Rainfall at Allahabad is evenly distributed throughout the day in winter and monsoon seasons with a tendency for double maxima, one near about mid-night/early morning hours and the other in the afternoon. During March, April, October and November the maximum is in the afternoon evening hours while in May and December it is in the early morning.

At New Delhi (Table 8) the maximum is in the afternoon/evening hours during November to May. In the monsoon months of July to August it has double maxima, one in the morning hours and other in the afternoon, though the former is less pronounced. Jodhpur gets appreciable rainfall only in monsoon months. Rainfall maximum lies in the afternoon/evening hours in all these months. Rainfall at Poona is almost evenly distributed during July and August with a slight tendency for double maxima, one in the afternoon and the other in the early morning hours. In the months of March to June the maximum occurs in the evening/night hours.

At Nagpur the maximum occurs either in the afternoon/evening or night and early morning hours during January to May. There are two maxima in June and December, one in the afternoon and the other in the early morning.

TABLE 7

JAMSHEDPUR (42799)

Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0·1	0·4	2·0	0	0·7	9·5	6·5	10·9	3·8	2·8	0·6	0
1—2	0	1·0	0·4	0·7	0·2	8·9	8·3	9·4	4·3	3·9	0·4	0
2—3	0·2	0·6	1·2	0·1	0·1	6·9	12·6	9·5	6·3	2·7	0·6	0
3—4	0·7	1·0	0·6	0	0	5·1	15·2	6·1	8·7	4·4	1·4	0
4—5	0·4	0·2	0·2	0	0·3	5·6	13.8	6·6	5·6	2·3	0·7	0
5—6	0·3	0·6	0·1	0	0	8·5	7·2	9·6	7·4	2·6	1·1	0
6—7	0·4	0·2	0	0·5	0	6·8	9·7	9·2	5·2	2·8	0·5	0
7—8	0·4	0·1	0·1	0	0	5·6	8·7	8·1	7·2	3·2	0·4	0
8—9	0	0	0	0	2·5	5·6	7·1	5·7	7·2	1·3	0·1	0
9—10	0	0·4	0·3	0	0·2	6·0	8·5	7·9	8·2	2·5	0·2	0
10—11	0·1	0·6	0·1	0·1	0·2	7·4	8·6	8·9	7·3	1·5	0·1	0
11—12	0·3	0·2	0·1	0	0	7·0	15·0	9·7	9·7	2·3	0·1	0
12—13	0	0·5	0	0	0	9·3	10·8	16·5	15·9	3·6	0·1	0
13—14	0	0·3	0·3	0	0·4	11.4	16.2	20.3	19.2	4.8	0·1	0·3
14—15	0	0	0·6	0·9	5·1	16·1	16·3	23·2	17·9	4·8	0·5	0
15—16	0	1·1	0·7	3·2	10·8	20·7	24·5	23·6	18·5	6·6	0·4	0
16—17	0·1	0·5	1·4	4·6	10·4	25·6	31·4	22·8	12·8	4·8	1·8	0
17—18	0·7	0·1	2·9	2·1	9·2	17·0	29·5	18·0	8·7	2·3	0·4	0
18—19	1·1	1·5	3·1	3·4	5·0	15·8	22·2	16·8	10·4	2·7	0·3	0
19—20	0·5	0·3	1·9	1·7	4·8	8·9	18·7	13·6	6·3	1·8	1·2	0·2
20—21	1·2	0·3	2·1	0·5	3·9	8·3	13·5	10·6	7·6	3·0	0·5	0·6
21—22	0·1	2·0	2·0	2·3	1·5	3·9	13·3	13·0	6·3	0·9	0·6	0
22—23	0·4	1·5	2·0	0·8	1·8	9·4	10·7	9·9	6·1	3·1	0.6	0
23—24	0.5	1.4	3·0	0	0.7	5.4	7·5	6·3	7.8	2.2	1.9	0

TABLE 8

NEW DELHI (SAFDARJUNG) (42182)

Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0·4	0·1	0·3	0·2	0	0·9	4·2	4·1	1·4	2·6	0	0
1—2	0·5	0·6	0·2	0·1	0·4	1·3	5·8	6·3	3·5	2·7	0	0·1
2—3	0·3	0	0·3	0	0·6	1·2	5·5	8·3	3·5	4·5	0	0
3—4	0·7	0	0·1	0	0·1	0·6	11·7	11·0	4·4	1·2	0	0
4—5	0·9	0	0	0·2	0	0·8	10·3	17·3	2·3	1·2	0	0·3
5—6	0·7	0·4	0	0	0·4	1·1	8·4	12·1	1·7	0·9	0	0·1
6—7	1·0	0·5	0	0·1	0	2·4	8·8	9·4	3·8	1·3	0·1	0·1
7—8	1·3	0·5	0	0	0·5	2·3	8·3	9·5	4·0	1·7	0	0
8—9	1·4	0·4	0·2	0·3	0	1·4	8·0	8·4	12·9	1·7	0	0·2
9—10	0·7	0·6	0	0	0·3	1·0	8·9	10·8	4·9	2·7	0	0·1
10—11	0·6	0·5	0	0	0	0·5	6·7	12·1	5·0	2·5	0	0·2
11—12	0·3	0·4	0·1	0·2	0	0·8	7·0	15·7	7·7	0·8	0	0·1
12—13	0·3	0·2	0·1	0·1	0·1	0·4	11·7	12·4	4·7	1·0	0	0·4
13—14	0·7	0	0·1	0·3	0·1	0	15·6	7·0	8·5	1·9	0·5	0·6
14—15	0·4	0·2	0·1	0	0·3	3·0	8·2	8·4	6·7	1·0	0	0·5
15—16	1·6	0·5	0·6	0·3	1·3	4·8	4·8	9·6	12·5	0·6	0	0·6
16—17	1·6	0·3	2·0	0·1	1·5	2·7	14·5	6·7	7·9	0·2	0	0·2
17—18	2·7	0·6	1·1	0·9	0·2	1·4	6·0	10·3	10·1	0·7	0	0·5
18—19	2·2	0·2	2·0	0·5	0·4	0·2	2·6	4·4	5·6	1·0	0·1	0·7
19—20	0·5	0·1	1·9	0·1	0·1	0·8	3·2	3·4	6·0	0·3	0·2	0·1
20—21	0·3	1·1	1·9	0	0·2	0·7	4·8	3·3	4·9	0·7	0·1	0·1
21—22	0·3	0·6	0·6	0	0·9	0·3	1·7	4·2	1·9	0·5	0·1	0·6
22—23	0·4	1·1	0·9	0	0·4	0·2	1·6	3·9	3·7	1·0	0·1	0·1
23—24	1·2	1·5	1·7	0	0·3	0·7	4·2	5·8	4·7	2·0	0·1	0

TABLE 9

HYDERABAD (Begumpet Aerodrome) (43128)

Mean hourly rainfall (mm)

Hours (IST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0—1	0·1	0·2	0·3	0·5	0·9	8·4	8·9	16·1	7·1	3·9	0·5	0
1—2	0	0·1	1·1	2·2	3·0	6·5	7·2	1·4	7·7	5·0	3·4	0·1
2—3	0	0·1	0·7	4·0	1·8	4·6	7·0	6·5	6·5	4·2	1·2	0
3—4	0	0·4	0·1	1·1	1·2	2·3	5·8	5·7	9·1	4·7	0·3	0·7
4—5	0	0	0·1	1·1	0·4	3·7	5·6	6·9	6·2	2·2	0·4	0·1
5—6	0	0	0·1	0·1	0·8	3·8	4·6	4·7	5·8	0·8	0·2	0
6—7	0	0	0	0	1·3	1·1	3·0	3·5	3·5	1·5	0·1	0
7—8	0	0	0	0	0·6	1·2	3·5	2·6	4·3	1·6	0	0
8—9	0	0	0	0	0	0·5	2·6	2·6	1·9	1·2	0·2	0
9—10	0	0	0	0	0	0·4	2·0	2·7	6·2	1·0	0·4	0·2
10—11	0	0	0	0	0	0·9	1·9	3·2	3·6	1·2	0·6	0
11—12	0	0	0	0	0	1·3	3·1	1·4	3·1	2·9	0·6	0
12—13	0	0	0	0·9	0·2	2·0	2·9	3·1	5·6	2·6	0·6	0
13—14	0	0	2·5	0·6	0	2·0	5·9	4·8	7·7	5·1	0·6	0
14—15	0	1·2	2·0	0·4	1·1	2·0	11·7	5·1	6·1	4·8	0·7	0
15—16	0	0·5	0·2	0·7	2·7	7·9	11·2	8·6	7·9	4·9	0·5	0
16—17	0	0·3	0·9	2·1	2·0	6·5	9·9	12·1	9·0	4·1	0	0
17—18	0	0	1·1	2·1	1·5	5·9	12·9	9·1	10·2	4·5	2·4	0·1
18—19	0	0·2	0·6	4·2	1·8	8·6	10·9	9·4	9·9	4·2	2·3	0·6
19—20	0	0	1·0	2·9	2·8	6·0	14·0	9·6	1·5	5·6	0·8	0·8
20—21	0	0	0·8	1·2	1·6	6·0	15·8	11·2	6·8	3·7	3·0	1·0
21—22	0	0	0·5	0·9	1·1	3·5	14·3	10·9	8·8	2·1	1·6	0·8
22—23	0	0·6	0	0·8	0·2	4·1	12·1	9·5	12·7	4·3	0·5	0·5
23—24	0·1	0·4	0·1	1·0	3·3	4.4	13·5	8·6	10·6	3·2	0·4	0·1

Hyderabad (Table 9) experiences a very well marked diurnal variation with maximum in the afternoon and evening hours in all the months with a slight secondary maximum in the early morning hours.

A well marked increase in the hourly rainfall in the afternoon hours in premonsoon and post monsoon months shows that insolation plays a great part in setting up the convective activity. A secondary maximum in the morning during winter and rainy months shows that the radiational cooling from the cloud tops also plays a significant role in the rainfall mechanism. Drift of thunderstorm cells from the hilly areas may also give maximum in the late night or early morning hours but to trace such effects, examination from a denser network of stations is needed.

4. Summary

The rainfall over India has one of the following patterns of diurnal variation—

(1) *Afternoon/evening maximum* is, in general, caused by solar heating of the surface of the earth and is characteristic of thunderstorm rain. It is more predominant during summer and post monsoon months at inland stations all over the country. Elevated land accentuates the thundery activity. During southwest monsoon the afternoon maximum is very much suppressed over the areas where it is main rainy season. This may also occur over an isolated island due to convergence of sea breezes during summer.

(2) *Night/early morning maximum* is associated with coastal areas. On the coast, rainfall is affected by the drift of thunderstorm cells from seas and low level convergence due to land breeze opposing the synoptic wind. This effect is seen at Bombay, Madras (October to February) and Sagar Island (monsoon and post monsoon months). This also exists in valleys where cold winds from the mountains converge. Cherrapunji shows this effect. During the season with heavy clouding during night, a morning maximum may also exist due to radiational cooling from the top of the clouds. This effect is visible in the monsoon months at most of the stations.

(3) *Mid-day/afternoon maximum* is likely to be associated with a coastal station in summer having nearly calm synoptic winds. This effect is visible at Madras in March and April.

5. Acknowledgement

The author is very much indebted to Shri K. N. Rao, Deputy Director General of Observatories (Climatology and Geophysics), for his encouragement, keen interest and valuable guidance in the study. The author is also grateful to Shri S. M. A. Alvi, Meteorologist for his help. His thanks are also due to S/Shri R. W. Roberts, A.R. Puranik and P. Balaram for their help in data processing and to Shri P.T. Vaz for typing the manuscript.

REFERENCES

Bleeker, W. and Andre, M. J.	1951	*Quart. J. R. met. Soc.*, **77**, pp. 403.
Mulky, G. R.	1958	*Indian J. Met. Geophys.*, **9**, p. 403.
Pramanik, S. K. and Rao, K. N.	1952	*Mem. India met. Dep.*, **28**, Pt. IV.
Ramage, C. S.	1964	*J. Met*, **9**, p. 83.
Rao, K. N.	1960	*Mem. India met. Dep.*, **31**, Pt. II.
Rao, K. N. and Raman, P. K.	1958	Proc. Symp. Meteorological and Hydrological Aspect of Floods and Droughts in India, India met. Dep., p. 186.