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Some climatological characteristics of relative humidity in Bangladesh

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सार — 12 केन्द्रों के 30 वर्षों (1951-80) के जलवायविक आँकड़ों का प्रयोग करते हुए बंग्लादेश में सापेक्ष आर्द्रता के कुछ लक्षणों का अध्ययन किया गया है। ऐसा करते हुए सापेक्ष आर्द्रता के वार्षिक परिवर्तन, स्थानिक वितरण एवं दैनिक तथा वार्षिक विस्तार की जाँच की गई है। इस अध्ययन में ढाका और कुछ अन्य केन्द्रों के बीच पाई गई सापेक्ष आर्द्रता की एक जैसी विशेषताओं का विश्लेषण किया गया है। अन्ततः कुछ निर्धारित सीमाओं (75 प्रतिशत तथा उससे अधिक, 80 प्रतिशत तथा उससे अधिक, 85 प्रतिशत तथा उससे अधिक) में सापेक्ष आर्द्रता के आरम्भ तथा समाप्त होने की तिथि और उसकी अवधि पर विचार किया गया है। इसमें सिनॉप्टिक आधार पर कालिक और स्थानिक परिवर्तनों के कारणों के बारे में विस्तार से बताने का भी प्रयास किया गया है।

ABSTRACT. Using climatological data for 30 years (1951-1980) for twelve stations, some characteristics of relative humidity (RH) in Bangladesh have been studied. In doing so, annual variation, spatial distribution, diurnal and annual amplitudes of RH have been investigated. The correlation characteristics of RH between Dhaka and some other stations have been analysed. Finally, the date of beginning and ending and the duration of RH in some defined limits (above 75%, 80% and 85%) have been discussed. An attempt has also been made to explain the cause of temporal and spatial variations from synoptic point of view.

Key words — Relative humidity, National economy, Spatial & temporal variations, Synoptic process, Duration.

1. Introduction

Weather and climate are two important factors of the physical environment of mankind. Both weather and climate are characterised by certain physical elements. These elements are: temperature of air, atmospheric pressure, relative humidity (RH), wind speed, cloudiness, rainfall, dewpoint, wind direction, visibility etc. Among these, RH is an important element of weather. Relative humidity is defined as the ratio of the observed mixing ratio to that which would prevail at saturation at the same temperature (Byers 1959). It may also be said that RH is a relation of the quantity of water vapour present in the atmosphere at a particular temperature to the quantity of water vapour required for saturation at that temperature. In fact, RH shows the potentiality of water content in the atmosphere.

We are in constant interaction with the atmosphere. For our daily activities we are very much indebted to water that we obtain in the surface of the earth. We obtain this water mostly as the product of precipitation. As we know, water vapour rising up in the atmosphere through adiabatic cooling causes condensation, which in turn, falls down to the surface of the earth as precipitation. So, in order to study climatological potentiality of water content in the atmosphere at a particular place, it is very much essential to get an idea about the RH of that place.

Water vapour present in the atmosphere influences the evapotranspiration of plants. It also interacts with construction materials, affecting different engineering constructions and equipment. Natural evaporation from the human and animal bodies is constantly going on. Considering the above mentioned views, a climatological study of RH in Bangladesh has been accomplished in the present investigation. Results obtained here may be widely used in different fields of our national economy.

2. Materials and methods

In the present work, climatological data for twelve stations with the length of thirty years (1951-1980) have been used. Data have been obtained from the Meteorological Department of Bangladesh (Bangladesh Meteorological Department 1984). The data include mean monthly values of RH at 00, 06, 09, 12 and 18 UTC.

In the present work, modern climatological methods have been applied. In doing so, some standard text books (Mostafa 1989, Alisov *et al.* 1940, Conrad and Pollack 1950, Alisov *et al.* 1952 and Gulinova 1974) have been followed.

3. Results and discussion

3.1. *Mean monthly RH*

3.1.1. *Annual variation of mean monthly RH*

According to the pattern of the curves and as to the occurrence of the maxima and the minima, the following categories of annual variation of RH are detected.

Category A — In unipeaked variations (Fig. 1) the maximum of RH is found in June or July and the minimum of it in February or March for the stations Dhaka, Chittagong, Cox's Bazar, Comilla, Sylhet, Mymensingh, Bogra, Faridpur, Jessore, Barisal and Khulna.

Category B — In multipeaked variations (Fig. 1) the primary maximum is found in June or July and primary minimum in February or March, secondary maximum in December and secondary minimum in November for the station Rangpur.

From the above analysis, it is clear that category A of annual variation of RH is territorially dominant in Bangladesh. From the consideration of synoptic meteorology the annual variation of RH pattern may be explained in the following way.

Anticyclonic circulation and heat lows are frequent in Bangladesh and its surrounding areas in February and March. These weather processes are characterised by low RH (Mobassher 1981). From April, RH rises up due to the influence of the western disturbance/norwesters, multi-centered lows over India and adjoining area and tropical cyclones. With the advent of southwest monsoon in Bangladesh in May, the frequency of these synoptic processes is increased causing rapid rise of RH. In June, southwest monsoon sets in Bangladesh and RH attains the maximum value due to the influence of the monsoonal weather processes. In July and August, RH remains very near to the maximum due to the influence of these weather processes. In September, the periphery of Asiatic anticyclone introduces in Bangladesh which lowers down RH. An increase in the frequency of the Asiatic anticyclone observed in October and December accelerates the rate of fall of RH (Mobassher 1981).

3.1.2. *Spatial distribution of RH*

Mean monthly RH (Table 1) values are analysed to show the features of the mean monthly RH in Bangladesh. It has been observed that in December and January the mean monthly RH is almost uniform throughout the country except in the region of Rangpur. In February, RH rises towards the northwestern and southeastern regions of the country from the centre. In March-May, the lower values of RH are observed at northwestern region of Bangladesh and it rises gradually towards the southeastern part. In June-October, RH is almost uniform throughout the country. In November, the highest value of RH is marked at Rangpur and it gradually decreases towards the southern part of Bangladesh.

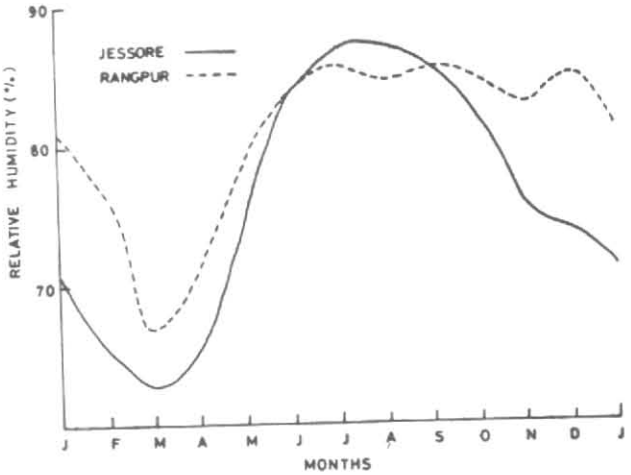

Fig. 1. Annual variation of the mean monthly relative humidity (%) at Jessore and Rangpur

3.2. *Annual distribution of RH*

The mean annual RH in different stations at different time (00, 06, 09, 12, 18 UTC) may be obtained in Table 2. Analysis shows that at 00 UTC, RH varies from 89 to 92%. At 06 UTC, it varies from 59 to 69%, 55 to 59% at 09 UTC, 67 to 77% at 12 UTC and from 83 to 90% at 18 UTC in Bangladesh. The mean annual RH is almost uniform throughout the country (76-81%).

3.3. *Amplitude of relative humidity*

3.3.1 *Mean diurnal amplitude*

Diurnal amplitude of RH is defined as the difference between the highest and the lowest values over the span of a day. The mean diurnal amplitude is obtained from the difference of the highest and the lowest values of RH in the interval of a month, since the mean monthly values of RH at a particular

TABLE 1

Mean monthly RH (%) for some stations of Bangladesh

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dhaka	69	63	61	70	79	86	86	85	85	81	75	73
Chittagong	72	71	75	79	81	86	87	85	85	83	78	76
Cox's Bazar	71	72	75	77	80	87	89	89	86	83	77	74
Comilla	73	70	71	76	81	86	87	87	85	82	78	76
Sylhet	71	65	63	73	81	88	87	87	86	83	77	74
Mymensingh	74	69	66	70	78	86	86	85	85	83	78	77
Rangpur	81	77	67	71	79	84	86	85	86	85	83	84
Bogra	71	62	56	60	74	85	87	86	85	82	76	74
Faridpur	75	65	59	69	75	86	87	86	85	82	78	77
Jessore	71	66	63	66	74	84	87	87	86	82	76	74
Khulna	71	69	67	73	77	86	89	88	87	82	73	74
Barisal	75	73	71	77	80	86	88	88	87	85	79	77

TABLE 2

Mean annual RH (%) for some stations of Bangladesh at different time (00, 06, 09, 12 and 18 UTC) and their average

Stations	Mean annual RH (%) at (UTC)					
	00	06	09	12	18	Average (%)
Dhaka	91	61	57	67	85	76
Chittagong	91	66	65	75	88	80
Cox's Bazar	90	68	69	77	87	80
Comilla	92	66	62	73	89	79
Sylhet	90	66	60	67	87	78
Mymensingh	89	68	61	68	88	78
Rangpur	90	69	62	71	86	81
Bogra	89	61	57	67	84	75
Faridpur	90	66	62	73	73	83
Jessore	91	59	55	68	85	76
Khulna	91	64	61	70	87	78
Barisal	92	67	66	73	90	80

period of a day are obtained from the mean of the daily values for that defined period. In this paper, the mean monthly RH at 00, 06, 09, 12 and 18 UTC has been calculated. From these values, the mean diurnal amplitudes have been obtained (Table 3).

(*a*) *Annual variation*

According to the pattern of the curves of the mean diurnal amplitude of RH, the following types are identified.

Category A — In unipeaked variation (Fig. 2) the maximum mean diurnal amplitude is observed in January or February and the minimum is observed in June or July for the stations Dhaka, Chittagong, Cox's Bazar, Comilla, Faridpur, Jessore, Barisal, Bogra and Khulna.

Category B — In double peaked variation (Fig. 2), primary maximum of the mean diurnal amplitude is observed in February or March and primary minimum is seen in June or July. Secondary maximum of the mean diurnal amplitude is observed in December and secondary minimum is seen in September for the stations Rangpur, Mymensingh and Sylhet.

Spatial distribution of the categories shows that Category A is dominant in Bangladesh. Category B is, however, prominent in the northern part of the

country. From the analysis, it is clear that the maximum fluctuation of the mean diurnal amplitude of RH is observed in January or February (when the winter monsoon is active) and the fluctuation of the mean diurnal amplitude is minimum in June or July (when SW monsoon is active).

(*b*) *Spatial distribution*

Analysis shows (Table 3) that in January and February the zone with the highest amplitude is situated in the central areas decreasing towards the north and the south. The minimum is observed in Rangpur. In March to June and in October the zone with the highest amplitude is observed in the northeastern part of Bangladesh. It gradually increases towards the southwestern part. In July, August, September, November and December the diurnal amplitude of RH is almost uniform.

3.3.2. *Annual amplitude*

Annual amplitude is defined as the difference between the highest and the lowest mean monthly values of RH in the range of the year. Analysis of the spatial distribution of annual amplitude of RH shows that (Table 3) the amplitude gradually decreases from the northwestern part of Bangladesh. The lowest value is seen in the southeastern hilly districts (16%) while the maximum value (31%) is marked in the district Bogra.

3.4. *Correlation co-efficient of RH between Dhaka and other stations of Bangladesh*

In order to understand the 'representativeness' of meteorological stations of Bangladesh in case of RH, correlation characteristics have been studied. For this purpose, scatter diagrams (Dhaka *versus* other stations) have been drawn first. It is found that the relationship is linear. The correlation coefficients have been calculated and are shown in Table 4. The correlation coefficients between Dhaka and other stations vary from month-to-month. If the correlation coefficient between a particular pair of stations is significant in one month, it may be weak in another month. However, the different stations are satisfactorily correlated with Dhaka in most of the months of the year. The annual variation of the correlation coefficient of RH between Dhaka and other stations shows that the annual variation pattern is very irregular.

Some regression equations have been obtained in Table 5.

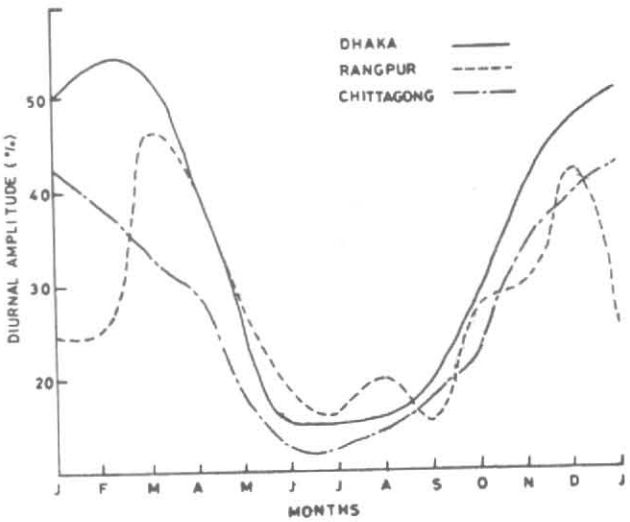

Fig. 2. Annual variation of diurnal amplitude (%) of relative humidity at Dhaka, Chittagong and Rangpur

3.5. *Number of days with RH in defined limits*

The dates of the beginning and ending of RH in defined limits are obtained by graphical method. For the purpose, the scale is chosen in such a way that each of the day of the month may be clearly differentiated. Then the mean monthly values are put in the graph to obtain an annual variation curve. From that curve the dates of passing the defined limits are recorded. The date in the rising curve gives the date of beginning and the date in the falling curve gives the date of ending.

The number of days with RH in the limit 75% & above, 80% & above and 85% & above have been analysed (Table 6). From the results, the date of beginning, the date of ending and the duration of the above mentioned limits have been analysed.

3.5.1. *Number of days with RH in the limit 75% and above*

From the analysis of the spatial distribution, it is clear that the earliest beginning of RH in the limit of 75% and above (6 April) is observed in Barisal and its surrounding areas. The onset of this limit gradually spreads towards the northwest and southwest regions. It reaches the northwestern part on 19 May while it covers the southeastern part of the country on 15 May. Thus, 43 days are required for the beginning of RH in the limit of 75% and above.

The date of ending in the limit of 75% and above lies between 7 November to 19 February. The

TABLE 3

Mean diurnal and annual amplitudes of RH (%) for some stations of Bangladesh

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Dhaka	50	54	53	41	27	15	15	16	20	29	40	47	25
Chittagong	42	38	33	30	19	13	13	14	18	23	34	39	16
Cox's Bazar	38	34	29	22	16	8	8	8	14	20	30	35	18
Comilla	51	49	41	29	21	15	16	16	20	26	37	45	17
Sylhet	44	46	42	30	22	15	16	21	20	25	38	42	24
Mymensingh	43	46	37	31	22	14	16	17	15	24	39	45	20
Rangpur	25	25	46	41	28	19	16	20	16	28	30	41	19
Bogra	43	49	48	44	30	20	15	17	19	26	38	42	31
Faridpur	43	44	43	35	29	14	12	14	15	25	34	39	28
Jessore	49	53	52	49	39	20	15	17	20	35	41	46	24
Khulna	39	46	45	36	30	15	14	16	15	28	37	49	22
Barisal	42	44	42	30	23	18	8	9	14	21	31	39	17

TABLE 4

Correlation coefficients of relative humidity between Dhaka and other stations

Pair of stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dhaka-Chittagong	0.62	0.37	0.55	0.42	0.54	0.41	0.22	0.25	0.57	0.34	0.36	0.17
Dhaka-Cox's Bazar	0.30	0.26	0.40	0.27	0.39	0.33	0.12	0.23	0.23	0.48	0.30	0.08
Dhaka-Comilla	0.60	0.13	0.56	0.38	0.17	0.61	0.35	0.49	0.41	0.56	0.38	0.38
Dhaka-Sylhet	0.51	0.39	0.34	0.60	0.20	0.30	0.24	0.40	0.36	0.57	0.17	0.32
Dhaka-Mymensingh	0.58	0.43	0.58	0.65	0.76	0.64	0.50	0.47	0.46	0.49	0.35	0.39
Dhaka-Rangpur	0.18	0.05	0.39	0.42	0.70	0.63	0.42	0.40	0.17	0.27	0.15	0.23
Dhaka-Bogra	0.34	0.39	0.41	0.67	0.86	0.68	0.46	0.20	0.40	0.55	0.20	0.35
Dhaka-Faridpur	0.79	0.57	0.67	0.73	0.59	0.56	0.54	0.56	0.29	0.69	0.49	0.38
Dhaka-Jessore	0.65	0.34	0.54	0.63	0.38	0.64	0.65	0.48	0.50	0.59	0.48	0.28
Dhaka-Khulna	0.70	0.37	0.67	0.46	0.60	0.13	0.12	0.25	0.08	0.50	0.25	0.20
Dhaka-Barisal	0.38	0.48	0.82	0.31	0.34	0.16	0.28	0.37	0.35	0.62	0.42	0.34

TABLE 5

Values of m and c in the model equation $Y = mX + c$ showing relation of RH between Dhaka (Y) and some other stations (X) for different months

Pair of stations	January		February		March		April		May		June	
	m	c	m	c	m	c	m	c	m	c	m	c
Dhaka-Chittagong	0.56	29	0.49	28	0.79	4	0.94	−3	0.70	23	0.26	64
Dhaka-Cox's Bazar	0.27	50	0.24	46	0.56	20	0.58	25	0.49	40	0.29	61
Dhaka-Comilla	0.22	53	0.14	56	0.55	23	0.34	44	0.16	66	0.31	60
Dhaka-Mymensingh	0.35	43	0.39	36	0.49	30	0.51	32	0.68	26	0.53	40
Dhaka-Rangpur	0.66	64	0.03	60	0.19	49	0.25	52	0.52	38	0.40	53
Dhaka-Bogra	0.21	54	0.38	39	0.37	41	0.43	44	0.47	44	0.23	67
Dhaka-Faridpur	0.50	32	0.64	22	0.70	23	0.60	38	0.35	53	0.35	56
Dhaka-Jessore	0.33	45	0.37	49	0.62	23	0.65	27	0.31	56	0.37	55
Dhaka-Khulna	0.39	41	0.31	42	0.81	7	0.52	32	0.45	44	0.08	81
Dhaka-Barisal	0.29	47	0.57	22	0.86	01	0.43	37	0.08	72	0.15	73
Dhaka-Sylhet	0.31	47	0.43	35	0.35	40	0.63	34	0.29	55	0.34	56

TABLE 5—(*Contd.*)

Pair of stations	July		August		September		October		November		December	
	m	c	m	c	m	c	m	c	m	c	m	c
Dhaka-Chittagong	0.12	73	0.20	69	0.77	19	0.74	20	0.35	48	0.21	57
Dhaka-Cox's Bazar	0.06	81	0.22	66	0.21	67	0.86	10	0.40	44	0.05	69
Dhaka-Comilla	0.15	73	0.25	64	0.31	58	0.66	27	0.33	49	0.21	57
Dhaka-Mymensingh	0.35	55	0.34	57	0.49	43	0.57	34	0.30	51	0.28	51
Dhaka-Rangpur	0.33	57	0.23	66	0.20	68	0.29	56	0.18	63	0.14	61
Dhaka-Bogra	0.37	53	0.18	70	0.75	43	0.75	20	0.35	49	0.47	48
Dhaka-Faridpur	0.46	46	0.59	35	0.31	58	0.96	02	0.74	17	0.63	24
Dhaka-Jessore	0.50	41	0.45	47	0.42	49	0.57	34	0.44	42	0.19	58
Dhaka-Khulna	0.07	81	0.17	71	0.07	79	0.65	28	0.38	47	0.19	58
Dhaka-Barisal	0.18	70	0.37	53	0.41	49	0.91	03	0.51	35	0.40	42
Dhaka-Sylhet	0.17	71	0.32	58	0.31	58	0.92	05	0.27	53	0.40	44

TABLE 6

Number of days with RH (%) in defined limits for some stations of Bangladesh

Stations	RH 75% and above			RH 80% and above			RH 85% and above		
	Beginning	Ending	Duration (days)	Beginning	Ending	Duration (days)	Beginning	Ending	Duration (days)
Dhaka	1 May	15 Nov	198	20 May	22 Oct	155	10 Jun	15 Sept	97
Chittagong	14 "	22 Dec	283	30 Apr	3 Nov	187	9 "	15 "	98
Cox's Bazar	15 "	3 "	263	15 May	30 Oct	168	7 "	27 "	112
Comilla	10 Apr	27 "	261	10 "	1 Nov	175	7 "	15 "	90
Sylhet	21 "	4 "	227	11 "	31 Oct	175	2 "	27 "	119
Mymensingh	5 May	8 Jan	268	21 "	3 Nov	166	10 "	15 "	97
Rangpur	28 Apr	19 Feb	297	19 "	21 Jan	247	25 "	16 Oct	113
Bogra	17 May	15 Dec	192	29 "	27 Oct	151	14 "	15 Sept	92
Faridpur	15 "	15 Jan	246	26 "	1 Nov	158	10 "	15 "	97
Jessore	19 "	1 Dec	196	3 Jun	27 Oct	146	23 "	23 "	92
Khulna	29 Apr	7 Nov	192	27 May	22 "	148	11 "	27 "	110
Barisal	6 "	15 Jan	284	15 "	11 Nov	180	11 "	14 Oct	125

earliest date of ending arises in Khulna (7 November) and the latest date of ending is found in Rangpur (19 February). Thus, 93 days are required for the ending of the RH in the limit of 75% and above.

Analysis shows that the smallest duration (192 days) of RH, in the limit of 75% and above, is marked in Khulna while the longest duration is seen in Rangpur. The duration increases towards the western half of Bangladesh except Rangpur (297 days) where an isolated zone is marked.

3.5.2. *Number of days with RH in the limit of 80% and above*

The earliest beginning of RH in the limit of 80% and above is observed in Chittagong (30 April) and its surrounding areas. The onset of this limit gradually spreads towards north and southwestern part of the country. It reaches the southwestern part of the country on 3 June. Thus, 34 days are required for the beginning of RH in this limit.

The earliest ending is marked on 22 October which is found in Khulna and Dhaka. The latest ending is observed in Rangpur (21 January). The date of ending of RH in this limit lies between October and November except in Rangpur. Thus, the date of ending is spread over 20 days except in Rangpur where it spreads over 91 days.

The duration of RH in the limit of 80% and above lies between 146 and 247 days. The shortest duration is observed in Jessore and its surrounding areas. The duration gradually increases towards the eastern part of Bangladesh except Rangpur where the longest duration (247 days) is marked.

3.5.3. *Number of days with RH in the limit of 85% and above*

Analysis shows that the date of beginning of the RH in the limit of 85% and above is spread over a few days. The earliest beginning is observed in the eastern part (2-9 June) of Bangladesh while the latest beginning is seen in the western part (11-25 June) of the country. Thus, 23 days are required for the beginning of RH in this limit.

From the analysis of the spatial distribution, the date of ending of this limit of RH is seen to lie

between September and October in several districts of Bangladesh. The earliest date of ending of this limit is 15 September and the last date of ending is 16 October (in Rangpur). Thus, the ending of RH in the limit of 85% and above requires 31 days.

The smallest duration (90—97 days) of the RH in this limit is found in the central and surrounding areas of Bangladesh. The duration increases towards the north as well as south from the central region. The longest duration is observed in Barisal (125 days)

4. Conclusions

(*i*) In the annual variation of RH in Bangladesh, the maximum is observed mainly in June or July and the mimimum of it in February or March.

(*ii*) The annual variation of RH agrees well with the variation pattern of synoptic process over the country. The minimum is observed when the synoptic processes like heat lows and the periphery of Asiatic Anticyclone are dominant and the maximum is observed when monsoonal weather processes are prominent.

(*iii*) The RH is almost uniform throughout the country in December, January, June, July, August, September and October. In February, March, April and May the lower values of RH are observed in the northwestern part of Bangladesh.

(*iv*) The mean annual RH is almost uniform throughout the country (76-81%).

(*v*) The mean diurnal amplitude of RH is usually maximum in January or February and minimum in June or July for the majority stations of Bangladesh (except Mymensingh, Rangpur and Sylhet).

(*vi*) In July, August, September, November and December the mean diurnal amplitude of RH is almost uniform throughout the country. In March to June and in October, the zone with the highest amplitude is observed in the northeastern part of Bangladesh.

(*vii*) The annual amplitude of RH varies from 16 to 31%. The values gradually decrease from the northwestern part to the eastern part of Bangladesh.

(*viii*) The date of the stable beginning of RH in the limit of 75% and above is recorded from 6 April to 19 May over the country. The date of ending of this limit is in between 7 November to 19 February. The longest duration of this limit is 297 days (in Rangpur) and the smallest one is 192 days (in Khulna).

(*ix*) The date of stable beginning of RH in the limit of 80% and above is from 30 April to 3 June and the date of ending is from 22 October to 21 January. The duration lies between 142 days to 247 days.

(*x*) The date of stable beginning of RH in the limit 85% and above is from 2 to 25 June and the date of ending is from 15 September to 16 October. The duration varies from 9 to 125 days.

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