

Nor'wester over West Bengal and comfortability

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सार – कोलकाता का मौसम मानसून पूर्व महीनों-मार्च, अप्रैल तथा मई के दौरान उच्च तापमान तथा सापेक्षिक आर्द्रता के कारण आमतौर पर बहुत ही बेचैनी वाला होता है। इस ऋतु के दौरान कोलकाता उत्तरी पश्चिमी विक्षोभों से प्रभावित रहता है। सामान्यतः उत्तरी पश्चिमी विक्षोभों को कष्टदायक मौसम गतिविधि के रूप में परिभाषित किया गया है। स्थानीय भाषा में इसे 'कालबैसाखी' कहा जाता है क्योंकि बंगाली बैसाख (अप्रैल-मई) के दौरान यह बंगाल के लिए 'काल' अथवा विनाशकारी होता है। यद्यपि उत्तरी पश्चिमी विक्षोभों से उत्पन्न अधोप्रवाह ठंडी हवाएँ लाता है और कभी-कभी तापमान 8 से 9 डिग्री सेल्सियस तक गिर जाता है और वातावरण कुछ अवधि के लिए आरामदेह हो जाता है। उत्तरी पश्चिमी विक्षोभों का यह बिल्कुल ही भिन्न और साकारात्मक पहलू है।

मनुष्य की आरामदायकता उसके शारीरिक प्राचलों के अतिरिक्त अनेक मौसम प्राचलों पर निर्भर करती है। यद्यपि विशेष रूप से उष्णकटिबंधीय क्षेत्रों के लिए वायु तापमान और सापेक्षिक आर्द्रता प्राथमिक मौसम कारक होते हैं। इस विषय पर अनेक शोधकर्ताओं ने शोध कार्य किया है जिसमें थाम (1957, 1958) का फार्मूला ऊष्मीय सूचकांक (टी. एच. आई.) अथवा बेचैनी सूचकांक (डी. आई.) के लिए सर्वमान्य है जो शुष्क बल्ब तथा आर्द्र बल्ब के तापमान की क्रिया पर आधारित है। डिग्री फारेनहाइट में टी. एच. आई. अथवा डी. आई. का तापमान = $0.4 (टी ए + टी डब्ल्यू) + 15$ है और डिग्री सेल्सियस में तापमान $0.72 (टी ए + टी डब्ल्यू) + 40.6$ है। आरामदायकता के विभिन्न चरणों को इस प्रकार वर्गीकृत किया गया है जैसे- (i) बेचैनी (ii) आंशिक बेचैनी और (iii) आरामदेह। पवन के प्रभाव को नजर अंदाज करते हुए तथा बेचैनी सूचकांक के समीकरण को और सरल करते हुए (टी ए + टी डब्ल्यू) की परिसीमा तापमान वृद्धि के क्रम में 27 से 55 तक बदलती रहती है।

मानसून पूर्व महीनों के दौरान जब कोलकाता की जलवायु उमसवाली तथा बेचैनी वाली हो जाती है तब वहाँ के लोग क्षणिक राहत के लिए सामान्यतः उत्तरी पश्चिमी विक्षोभों के आगमन की इच्छा करते हैं यद्यपि इसका परिणाम विनाशकारी होता है। उत्तरी पश्चिमी विक्षोभों के आगमन के बाद मौसम 10 से 12 घंटे के लिए और कभी-कभी पूरे दिन तक आरामदेह रहता है। इस शोध पत्र के लिए कोलकाता के अलीपुर तथा दमदम, दोनों स्थानों के पिछले छः वर्षों के आंकड़े लिए गये हैं। इससे यह पता चला है कि मार्च में प्रातः काल को छोड़कर मानसून पूर्व ऋतु की शेष अवधि जलवायु की दृष्टि से बेचैनी वाली होती है। इस शोध पत्र में 91 बार की तूफानी बौछारों का अध्ययन किया गया है और पाया गया है कि अधिकतर तूफानी बौछारें अप्रैल और मई के महीनों में आई हैं और अधिकांश अवसरों पर उत्तरी पश्चिमी विक्षोभों से अप्रैल माह में लगभग पूरा दिन आरामदेह बना रहा है। उत्तरी पश्चिमी विक्षोभ की सक्रियता मई के अंत में भी कोलकाता और उसके समीपवर्ती क्षेत्रों के लोगों को राहत पहुँचाती है किन्तु तुलनात्मक रूप से बहुत कम होती है।

ABSTRACT. During the pre-monsoon months of March, April and May the weather over Kolkata is generally very uncomfortable due to high temperature and relative humidity. During this season Kolkata is affected by the nor'wester activity. Generally the nor'wester activity is defined as a disastrous weather activity and is locally called as 'Kaalbaisakhi' as it is 'kaal' or destruction during Bengali Baishakh (April-May) month over Bengal. However the downdraft associated with the nor'wester brings cool air and temperature sometimes drops by as much as 8 to 9 degree Celsius and the atmosphere becomes comfortable for some period. This is an entirely different and positive aspect of nor'wester.

The human comfortability depends upon many weather parameters apart from human physiological parameters. However the primary weather factors are air temperature and relative humidity especially for tropical areas. Many authors have worked on this and the well accepted formula for thermal index THI or Discomfort Index DI is taken from Thom (1957,1958) which is a function of dry bulb and wet bulb temperature i.e., THI or DI = $0.4 (Ta + Tw) + 15$ where temperature is in °F and is $0.72 (Ta + Tw) + 40.6$ where temperature is in °C. Various stages of comfortability are classified viz., (i) Discomfortable (ii) Partial discomfortable and (iii) Comfortable. Neglecting the effect of wind and

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further simplifying the equation for DI as a function of $(T_a + T_w)$ the range varies from 27 to 55 in increasing order of temperature.

During the pre-monsoon months when the climate over Kolkata is very sultry and uncomfortable, people generally desire the onset of nor'wester for some temporary relief although it results into destruction. The nor'wester makes the weather comfortable after its occurrence and remains comfortable for 10 to 12 hours and some time even for a day. The present study is made taking six years data over Kolkata, both Alipore and Dum Dum. It is seen that except early morning of March the remaining period of pre-monsoon season is found to be uncomfortable climatologically. In the present study there were 91 occasions of squalls and it is found that most of the squalls occurred during the month of April and May and on most of the occasions nor'wester made the weather comfortable for a large part of the day in the month of April. By the end of May nor'wester activity also brought relief but not to that extent as in March and April to the people of Kolkata and neighbourhood.

Key words – Kaalbaishakhi, Comfortability, Discomfort Index.

1. Introduction

March, April and May are known meteorologically as pre-monsoon months or hot weather months. These months are significant over West Bengal specially due to on set of nor'wester. Nor'westers are strong northwesterly winds from the thunderclouds during pre-monsoon seasons over West Bengal. They accompany thunderstorms occurring during the season. Of course all the thunderstorms do not lead to nor'westers but severe thunderstorms mostly are accompanied with nor'westers or squalls. The squalls are generally stronger during 15th April to 15th May, the month of Baisakh of West Bengal and these nor'westers are commonly called as kaalbaisakhi, kaal means destruction. Thus, these nor'westers are primarily well known as destructive weather phenomenon. Generally these nor'westers leave signs of severe destruction over the area through which it passes, still some people desire the approach of kaalbaishakhi mainly because these are accompanied with cold air some times as cold as it make the environmental temperature fall by 9 to 10 degrees Celsius converting the highly uncomfortable and sultry weather into a cool comfortable weather at least for the night following the evening on which the nor'wester occurs.

The present study is therefore an entirely different approach to the surface property of nor'wester over West Bengal. Assuming normal values during the pre-monsoon season as:

Maximum temperature = X_{mi} ; normal maximum temperature $[X]_{mi}$

Minimum temperature = X_{nj} ; normal minimum temperature = $[X]_{nj}$

Maximum R.H. = H_{mi} ; normal maximum R.H = $[H]_{mi}$

and

Minimum R.H. = H_{nj} ; normal minimum R.H = $[H]_{nj}$

where i, j = 1,2,3 for the months March, April and May respectively.

The following parameterisation can be made for the normal range of Discomfort Index (DI) during pre-monsoon months. The normal values of maximum and minimum temperatures can be obtained from the Climatological normals and the normal values of maximum and minimum relative humidity can be obtained from Chakrabarty (1988). The maximum relative humidity generally occurs during the occurrence of minimum temperature and *vice versa*. The wet bulb temperature corresponding to maximum and minimum temperature can be found out using hygrometric table. Let wet bulb temperature corresponding to X_m be W_m and X_n be W_n . From Thom (1957) DI is a function of dry bulb and wet bulb temperature, in other words for pre monsoon months

$$DI = f(X, W)$$

Putting various values of X and W the normal values of maximum and minimum values of 'DI' for March, April and May can be worked out and it may be seen that the 'DI' varies between two values 'a' and 'b' both of which indicate that the atmosphere is normally uncomfortable throughout the day during pre-monsoon season [Table 1(c)].

Thus the people become quite exhausted, tired and restless and sometimes pray for 'kalbaisakhis'.

Chakrabarty (1982) observed that a multiple squall during mid month of April the temperature fell to that extent that people wore woolen garments. These led the authors to study the changes in DI before and after occurrence of squalls.

In the first place of study six years data from 1999 to 2004 over Kolkata (Alipore) and Kolkata airport (Dum Dum) has been taken and fairly encouraging results are found.

2. Comfortability

The phenomenon comfort depends upon various weather parameters and behavioural adjustment of human beings to balance energy exchanges between the body and the environment. So as to maintain a constant temperature of 37° C. Mathematically all of these may be combined into the form (Gagge 1936) :

$$(M + Q) \pm R \pm C - E = \pm S \text{ (Wm}^2\text{)}$$

where,

M = Metabolic heat energies used in work

Q = Incoming short wave solar radiation

R = Long wave solar radiation

C = Convection

E = Evaporation

S = Storage within body tissue

For the maintenance of humenothermy, 'S' should be equal to zero over time.

As such the comfort need to be quantified by two personal and four environmental parameters *viz.*, metabolic rate, clothing insulation, air temperature, radiant temperature of surroundings, rate of air movement (wind) and atmospheric humidity. Considering various relations and using proper algorithm the indices can be reproduced by a single value. However, the indices need to assume different mathematical calculation in cold and warm conditions. Szokolay (1985) made a social survey and by using comfort rate techniques has differentiated among those found experimentally.

During winter the outdoor parameter like wind chill effect and the humidity factors most commonly used for

cold K_o (Siple and Passel, 1945) and temperature humidity index (TH, or Discomfort Index, DI as called by US weather services) for hot condition Thom (1957, 1958) expressed as follows :

$$K_o = 11.62 (\sqrt{V + 1.45} - 0.1 V) (33 - T_a) \text{ (}^\circ\text{C)}$$

$$\text{THI} = 0.72 (T_a + T_w) + 40.6 \text{ (}^\circ\text{C)}$$

$$\text{THI} = 0.4 (T_a + T_w) + 15 \text{ (}^\circ\text{F)}$$

Where V is the wind speed in meter per second, T_a and T_w are air and wet bulb temperature respectively. According to others (WMO, 1972) the discomfort starts from T_a starting from 24° C when there is 100% relative humidity *i.e.*, wet bulb temperature T_w is also equal to 24° C. By simple study of various population the various stages of discomfort can be classified with increasing temperature in °C (Prasad and Power 1982).

$$\text{THI} = \text{DI} < 60 \quad \text{Discomfort}$$

$$65 \geq \text{DI} > 60 \quad \text{Partial discomfort}$$

$$75 \geq \text{DI} > 65 \quad \text{Comfort}$$

$$80 \geq \text{DI} > 75 \quad \text{Partial discomfort}$$

$$\text{DI} > 80 \quad \text{Discomfort}$$

Simplifying the formula by eliminating constants the equation for the discomfort index, it may be written in terms of sum of dry bulb (air) temperature and wet bulb temperature with increasing temperature and calling it discomfort index DI as :

$$\text{DI} = T_a + T_w$$

DI, so calculated, are classified as follows for Kolkata and neighbourhood

$$\text{DI} < 27 \quad \text{Total discomfort}$$

$$34 \geq \text{DI} > 27 \quad \text{Partial discomfort}$$

$$47 \geq \text{DI} > 34 \quad \text{Comfort}$$

$$54 \geq \text{DI} > 47 \quad \text{Partial discomfort}$$

$$\text{DI} > 55 \quad \text{Total discomfort}$$

TABLE 1(a)

Relative humidity and maximum and minimum temperature (Climatic normals for Kolkata)

Panted	March				Panted	April				Panted	May			
	Relative humidity		Temperature			Relative humidity		Temperature			Relative humidity		Temperature	
	Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.
13	92	32	31	18	19	92	34	36	24	25	90	47	36	26
14	91	31	33	20	20	87	35	36	24	26	88	49	36	26
15	90	27	34	21	21	90	37	36	25	27	91	50	36	26
16	91	30	35	22	22	90	39	36	25	28	91	48	36	27
17	92	33	35	22	23	91	40	36	25	29	91	50	36	27
18	91	33	35	23	24	91	44	36	26	30	91	50	35	27
Average	91	31	34	21.7		90	38	36	25.1		90	49	36	26.5

TABLE 1(b)

Monthly mean

Month	Relative humidity		Temperature		Wet bulb temperature		Temperature	
	Maximum	Minimum	Maximum	Minimum	Morning	Evening	0830 hr (IST)	1730 hr (IST)
March	91	31	34	22	20.7	22.2	26.6	30.6
April	90	38	36	25	23.9	25.3	30.0	32.2
May	90	49	36	26.5	25.2	27.4	31.2	32.3

TABLE 1(c)

Comfortability with respect to climatic normals (monthly mean values)

	Early morning			0830 hr (IST)			Afternoon			1730 hr (IST)		
	TT	TwTw	DI	TT	TwTw	DI	TT	TwTw	DI	TT	TwTw	DI
March	21.7	20.7	42.4 (C)	26.6	22.0	48.6 (PD)	34	22.2	56.2 (DC)	30.6	21.9	52.5 (PD)
April	25.1	23.9	49.0 (PD)	30.0	25.4	55.4 (D)	36.3	25.1	61.4 (D)	32.2	25.2	57.4 (D)
May	26.5	25.2	51.6 (PD)	31.2	26.9	58.1 (D)	36.0	27.4	63.4 (D)	32.3	26.7	59.0 (D)

C : Comfort, PD : Partial discomfort, D : Discomfort

3. Comfortability over Kolkata and neighbourhood

Kolkata (22° 32' N, 88° 20' E) is about 200 kilometer north of Bay of Bengal coast line and very near to

Sundarban, the Hooghly river delta. Tropical high temperature and humid condition makes all form of life very uncomfortable during summer months mainly April and May. However, during the month of March also high

TABLE 2(a)

Hours of comfort after and before squalls over Alipore and Dum Dum during March

Year	Alipore								Remarks	Dum Dum								Remarks		
	No of Squalls	Dates of squalls	Hours of comfort before squall			Hours of comfort after squall				No of Squalls	Dates of squalls	Hours of Comfort before squall			Hours of Comfort after squall					
			D	PD	C	C	PD	D				D	PD	C	C	PD	D			
1999	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	2	22	-	8	-	14	2	-	-	-	-
											29	5	6	-	13	-	-	-	-	-
2002	1	28	4	12	0	9	23	0	-	-	-	-	-	-	-	-	-	-	-	-
2003	2	5	8	7	3	29	0	0	Comfort before squall due to early morning squall in early March	4	12	0	6	0	40	2	0	Longer period of comfort due to 2 squalls on 12 th		
		27	7	3	0	13	24	0			19	4	6	0	14	24	0			
											27	0	4	0	24	24	0			
2004	-	-	-	-	-	-	-	-	-	1	10	2	6	0	30	9	0	Longer period of comfort due to squalls on early March		
Avg.	0.5	-	7	5	-	21	12	0	-	1.1	-	1.3	5	0	23	16.6	0	-		

D : Discomfort = DB + Wet bulb 55 or more; PD : Partial discomfort = DB + Wet bulb 48 to 54;

C : Comfort = DB + Wet bulb 34 to 47

TABLE 2(b)

Hours of comfort after and before squalls over Alipore and Dum Dum during April

Year	Alipore								Remarks	Dum Dum								Remarks		
	No. of Squalls	Dates of squall	Hours of comfort before squall			Hours of comfort after squall				No. of Squalls	Dates of data taken	Hours of Comfort before squall			Hours of Comfort after squall					
			D	PD	C	C	PD	D				D	PD	C	C	PD	D			
1999	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	4	15	5	0	0	15	9	-	-	4	12	4	12	0	7	24	-	-	-	-
		21	17	10	0	3	18	-	Very less comfort		21	11	10	0	3	23	-	Partial comfort at night		
		24	8	0	0	14	2	-			24	5	1	0	17	3	-			
		29	9	0	0	5	9	-	Very less comfort		29	9	0	0	7	8	-			
2001	1	5	9	0	0	10	3	-	-	4	6	8	1	0	15	1	-	-	-	-
											15	6	5	0	11	13	-	Partial Comfort at night		
											17	8	0	0	19	13	-			
											30	10	0	0	13	24	-			
2002	6	3	5	14	0	9	29	-	-	5	1	9	3	0	9	19	-	-	-	-
		10	10	1	0	13	0	-	Longer period of comfort due to squall on following day		3	0	0	5	22	2	-	Longer period of comfort due to squall on following day		
		11	8	1	0	18	15	-			8	7	2	0	9	5	-			
		12	7	5	0	11	17	-			10	6	5	0	12	-	-			
		22	14	0	0	9	11	-			12	0	5	0	11	12	-			
		24	9	2	0	10	11	-												
2003	3	5	10	3	0	9	2	-	Comfort before squall due to night squall in early March	1	30	8	2	0	12	24	-	-	-	-
		16	11	0	0	7	6	-												
		26	12	0	0	7	5	-												
2004	2	5	0	11	0	8	23	-	-	3	5	10	5	3	5	5	-	-	-	-
		7	0	6	0	10	11	-			21	12	2	0	10	2	-			
											23	8	2	1	12	24	-			
Avg.	2.7	-	8.9	1.8	0	10.1	10.4	-	-	2.8	-	7.6	3.4	0.7	11.4	11.9	-	-		

D : Discomfort = DB + Wet bulb 55 or more; PD : Partial discomfort = DB + Wet bulb 48 to 54; C : Comfort = DB + Wet bulb 34 to 47

TABLE 2(c)
Hours of comfort after and before squalls over Alipore and Dum Dum during May

Year	Alipore								Remarks	Dum Dum								Remarks
	No of Squalls	Dates of data taken	Hours of comfort before squall			Hours of comfort after squall				No of Squalls	Dates of data taken	Hours of comfort before squall			Hours of comfort after squall			
			D	PD	C	C	PD	D				D	PD	C	C	PD	D	
1999	-	-	-	-	-	-	-	-	-	2	9 15	16 11	3 10	0 0	4 4	7 2	- 10	-
2000	8	2 3 17 19 25 30	10 10 10 11 07 10	0 0 0 0 0 0	0 0 0 0 0 0	12 15 9 12 0 0	2 1 2 5 11 12	- - - 1 - -	Longer period of comfort due to squalls on consecutive days - Total discomfort -do-	6	2 3 3 14 17 21	10 10 5 5 7 6	0 1 1 0 2 2	0 0 0 0 0 0	13 14 7 5 5 11	2 23 5 11 11 16	- - - - - -	Squalls on consecutive days Squalls on consecutive days
2001	5	5 8 25 29 30	9 8 12 16 10	2 2 0 3 0	0 0 0 0 0	14 13 10 24 12	2 - - - -	4 - - - -	- - - - -	8	4 5 7 8 19 21 22 24	10 8 8 8 12 9 12 10	12 1 1 0 0 0 0 0	0 0 0 0 0 0 0 0	4 13 5 13 0 6 0 0	24 24 9 11 11 10 10 12	- - - - - - - -	- - - - - - Total discomfort
2002	3	3 23 27	11 11 10	4 0 8	0 4 0	7 12 6	1 18 2	- - -	- - -	7	2 3 23 24 27 27 31	11 10 11 2 9 9 7	0 3 0 0 10 1 0	0 0 0 0 5 0 0	17 8 10 10 2 12 0	3 1 0 11 11 2 1 16	- - - - - - -	- - - - - - Total discomfort
2003	3	20 21 24	15 9 10	0 1 1	0 0 0	1 14 12	0 1 2	- - -	Longer period of comfort due to squalls on consecutive days	2	9 20	15 9	0 0	0 0	4 13	5 0	- -	- -
2004	2	21 24	12 10	1 0	0 0	2 0	10 12	- -	No comfort at all	2	19 21	9 5	0 3	0 3	5 9	8 3	- -	Total discomfort
Avg.	3.2	-	10.5	1.1	0.0	6.5	7.1	0.3	-	4.7	-	9.9	2.1	0.1	7.1	9.0	-	-

D : Discomfort = DB + Wet bulb 55 or more; PD : Partial discomfort = B + Wet bulb 48 to 54; C : Comfort DB + Wet bulb 34 to 47

TABLE 2(d)

ALIPORE - Number of squalls hitting Alipore during the period from 1999 to 2004 and hours of comfort after individual Nor'wester activity. Hours of average comfort given in the brackets

Year	March						April						May					
	Morning		Evening		Night		Morning		Evening		Night		Morning		Evening		Night	
	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort
1999	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	4	7	-	-	-	-	7	7	1	0 (0)
										3 (6)						6		
										8						7 (5)		
										5						7		
																0		
																1		
																7		
2001	-	-	-	-	-	-	-	-	1	6 (6)	-	-	-	-	4	0	1	3 (3)
																7 (1.75)		
																0		
																0		
2002	-	-	-	-	1	7 (7)	1	7 (7)	2	7	3	7	-	-	1	7 (7)	2	6
										7 (7)		7 (6)						6 (6)
												4						
2003	1	7 (7)	1	7 (7)	-	-	-	-	2	6	1	6 (6)	-	-	2	6	1	3 (3)
										6 (6)						6 (6)		
2004	-	-	-	-	-	-	-	-	-	-	2	6 (6)	-	-	2	0	-	-
												6				2 (1)		

Morning : 0600-1200 hr (IST); Evening : 1200-2100 hr (IST); Night : 2100-0600 hr (IST)

TABLE 2(e)

DUM DUM - Number of squalls hitting Dum Dum during the period from 1999 to 2004 and hours of comfort after individual Nor'wester activity. Hours of average comfort given in the brackets

Year	March						April						May					
	Morning		Evening		Night		Morning		Evening		Night		Morning		Evening		Night	
	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort	No. of squalls	Hrs of comfort
1999	-	-	-	-	-	-	-	-	-	-	-	-	1	2 (2)	-	-	1	2 (2)
2000	-	-	-	-	-	-	-	-	2	6	2	6	1	1 (1)	5	7		
										7 (6.5)		0 (3)				7		
																7		
																0		
																6 (5.5)		
2001	-	-	1	12 (12)	1	8 (8)	-	-	4	7	-	-	1	4 (4)	6	7	1	0 (0)
										7						7		
										7						0		
										7 (7)						0		
																0		
																0 (2.3)		
2002	-	-	-	-	-	-	1	7 (7)	1	7 (7)	3	7	1	7 (7)	4	7	2	7
											7 (7)					7		5 (6)
											7					7		
																0 (5.3)		
2003	-	-	4	2	-	-	-	-	1	7 (7)	-	-	-	-	2	7	-	-
				7												4 (5.5)		
				7														
				5 (5.3)														
2004	-	-	1	7 (7)	-	-	-	-	2	7	1	4 (4)	-	-	2	3	-	-
										7 (7)						6 (4.5)		

Morning : 0600-1200 hr (IST); Evening : 1200-2100 hr (IST); Night : 2100-0600 hr (IST)

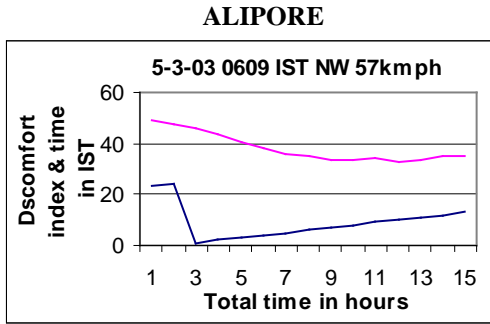


Fig. 1

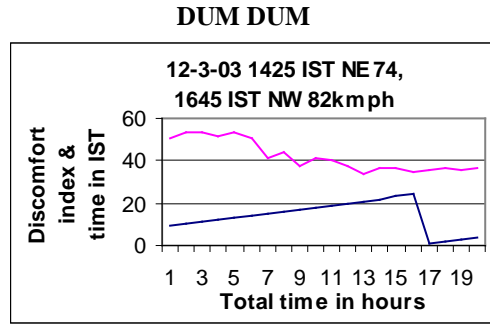


Fig. 4

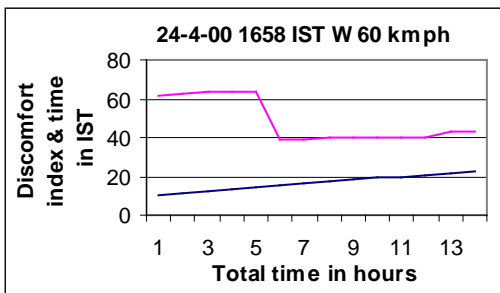


Fig. 2

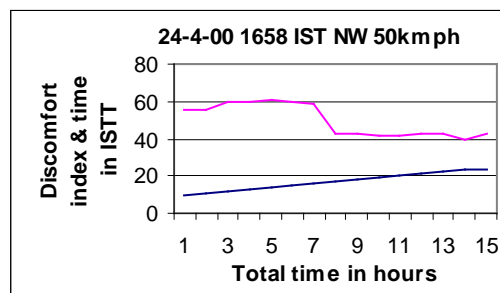


Fig. 5

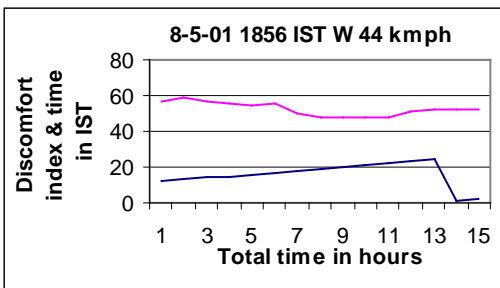


Fig. 3

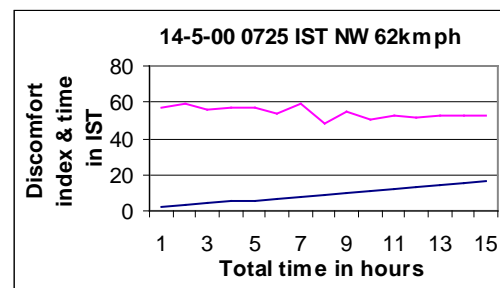


Fig. 6

Figs. 1 to 6. Represent comfort ability after nor'wester over Alipore (Figs. 1 to 3) and Dum Dum (Figs. 4 to 6) in the months of March, April and May

TABLE 3
Total number of squalls 91, (Alipore 40, Dum Dum 51)

Year	March		April		May		Annual total	
	Alipore	Dum Dum	Alipore	Dum Dum	Alipore	Dum Dum	Alipore	Dum Dum
1999	0	0	0	0	0	2	0	2
2000	0	0	4	4	8	6	12	10
2001	0	2	1	4	5	8	6	14
2002	1	0	6	5	3	7	10	12
2003	2	4	3	1	3	2	8	7
2004	0	1	2	3	2	2	4	6
Total	3	7	16	17	21	27	40	51

temperature and humid conditions rise the effective temperature (ET) to the level of discomfort as stated earlier. Meteorological parameters like surface air temperature, relative humidity, wind speed, radiation etc. largely determine the human comfort. These parameters varies largely over different parts of the globe. Even in India there is large variation of temperature, relative humidity, wind and radiation over different areas. However, for Kolkata and neighbourhood comfortability index has been calculated in terms of sum of air temperature T_a and wet bulb temperature T_w as shown in the below :

$T_a + T_w < 27$ Discomfort (Cold and dry condition)

$T_a + T_w \geq 27 \leq 33$ Partial discomfort

$T_a + T_w \geq 34$ but, ≤ 47 Comfort

$T_a + T_w \geq 48$ but, ≤ 54 Partial discomfort

$T_a + T_w \geq 55$ Total discomfort (Hot and moist condition)

However, these three months; March, April and May, are the months of nor'wester over Bengal. During this period a number of squalls pass over Kolkata and neighbourhood. Most of the times these squalls are accompanied by rain, thunderstorm and even hails. After passage of a squall over Kolkata and neighbourhood effective temperature comes down to comfortable level. In this study attempts has been made to find out length of comfortable period after nor'wester activity over Kolkata and neighbourhood with a view to add this factor while issuing local forecast for Kolkata and neighbourhood.

In the month of June nor'wester activities are occasionally seen over Kolkata and neighbourhood before southwest monsoon sets in. However this period has not been included in this study. Results of the study will equally hold good for this brief period also.

3.1. Comfortability over Kolkata during pre-monsoon months

A compilation is made for the normal values of discomfort index during pre-monsoon months of March to May over Kolkata (Alipore). The day is divided into four parts *viz.*, night or early morning when dry bulb or air

temperature is minimum, morning (0830 hr IST), afternoon when the day temperature is maximum and evening (1730 hr IST). The climatological normal table gives monthly values of dry bulb and wet bulb temperature at 0830 hr IST and 1730 hr IST and maximum and minimum temperature. Chakrabarty (1988) computed normal maximum and minimum values of relative humidity over Kolkata. Presuming that maximum relative humidity reaches at the early morning when minimum temperature occurs and *vice versa*, wet bulb temperatures are computed corresponding to maximum and minimum temperature referring to hygrometric table. Table 1(a) gives the panted normal of maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity for the months of March, April and May. Table 1(b) gives the monthly mean values of maximum and minimum temperature and relative humidity for March, April and May and values of wet bulb temperature at early morning and afternoon. It also gives the normal values of wet bulb temperature corresponding to 0830 hr (IST) and 1730 hr (IST). From Table 1(b), values of discomfort index at early morning, morning, afternoon and evening are computed for three months and tabulated in Table 1(c). The Table 1(c) indicates that the months of March, April and May are generally discomfortable except early morning of March when weather is comfortable. Early morning of April and May weather is partly discomfortable or in other wards partly comfortable.

4. Data and methodology

Occurrence of squalls in the months of March, April and May over two stations Alipore and Dum Dum for last six years, 1999 to 2004, has been chosen for the study. Hourly air temperature and relative humidity on the day of squalls and the day following have been collected from thermograph and hygrograph of Alipore and Dum Dum for the study period. From these hourly temperature and relative humidity data Discomfort Index (DI) for Kolkata and neighbourhood has been calculated by adding dry bulb and wet bulb temperature. Total number of hours of comfortability before squall, on the day of a squall, and subsequently following for both the stations have been calculated. Tables 2(a-c) show the hours of comfortability before and after squalls for the months of March, April and May respectively for the two stations under study. Time of squalls have been brought under three broad heads morning (0600 hr IST to 1200 hr IST), evening (1200 hr IST to 2100 hr IST) and night (2100 hr IST to 0600 hr IST). Average hours of comfortable weather have been calculated against occurrence of squalls during morning, evening and night over both the stations during

the month of March, April and May. This has been shown in Table 2(d) (Alipore) and Table 2(e) (Dum Dum).

Discomfort Index (DI) in respect of Kolkata and neighbourhood have also been plotted against time taking a period of seven hours before and seven hours period after each squall over both Alipore and Dum Dum. Graphical representation of all the squalls over both Alipore and Dum Dum during the study period have been prepared, a few of which for Alipore (Figs. 1 to 3) and Dum Dum (Figs. 4 to 6). Total number of squalls over both Alipore and Dum Dum has been given in Table 3.

5. Results and discussion

March

Number of squalls over Alipore and Dum Dum are very few in the month of March during the study period (1999 to 2004). On 12th March 2003 Dum Dum has been hit by two squalls within three hours, between 1400 hr IST and 1700 hr IST. Although Alipore was not hit by any squall on that day it can easily be presumed that gusty wind was blowing over Alipore. So next two days weather was more or less comfortable over Kolkata and neighbourhood. It can be seen from the graphical representation of comfortability that after occurrence of the squall on 5th March 2002 over Alipore Discomfort Index (DI) came down to even such a value (<34) which led to partial discomfort of winter climate for a few hours. Since the squall occurred very late in the night and beginning of the month thermal discomfort due to low temperature was felt. During the month of March weather remains comfortable for a longer period of time, at least for a day after nor'wester activity over Kolkata and neighbourhood (Alipore average 21 hours, Dum Dum average 23 hours) [Table 2(a)].

April

During the period from 2000 to 2004 Alipore was hit by 16 and Dum Dum by 17 squalls however 1999 was a squall free year for Alipore and Dum. All the nor'wester activities in the year 2000 over both Alipore and Dum Dum has shown prolonged hours of comfort except one that hit Dum Dum during night. Next year (2001) nor'wester activities over Dum Dum also produced comfortable weather for longer periods. In the year 2002 squalls reported by both Alipore (6) and Dum Dum (5) have shown long period of comfort over Kolkata and

neighbourhood except on two occasions when Dum Dum was hit by squall during night [Table 2(e)]. Squalls hitting both Dum Dum and Alipore during remaining study period has also shown long period of comfort except odd ones that hit during night [Table 2(b)]. During the month of April weather over Kolkata and neighbourhood remains comfortable for about 11 hours. Squalls hitting during evening hours have shown more comfort than those hitting in the morning and night [Table 2(b)].

May

The year 1999 was squall free year over Alipore. During 2000 – 2004 Alipore has been hit by 21 squalls. After occurrence of 12 squalls over Alipore weather was comfortable for little over seven hours to five hours. Remaining squalls have shown no comfort or very little comfort [Table 2(d)]. Squalls hitting Alipore during night, in particular, have shown comfort for short duration. In the month of May Dum Dum has been hit by more number of squalls (27). During the month of May Dum Dum has been hit by maximum number of squalls (8) in the year 2001 [Table 2(e)]. However, Dum Dum has been hit by 6 squalls during 2000 and 7 squalls during 2002. So far as comfort is concerned weather over Kolkata and neighbourhood was comfortable for about three hours only after passing of squalls during night. Same is the case with squalls passing during morning hours. However Squalls hitting Dum Dum during evening hours have shown somewhat better average of comfort hours [Table 2(e)]. In case of 8 squalls over Dum Dum there was prolonged period of comfort, around 10 to 12 hours duration . However remaining squalls over Dum Dum produced very low duration of comfort Average hours of comfort over Kolkata and neighbourhood was about 7.1 after nor'wester activity during the month of May [Table 2(c)].

6. Conclusion

Nor'wester activity was less prominent during the first month, March, of the pre-monsoon season. In the year 1999 there was no nor'wester activity over Alipore, only two squalls have been recorded over Dum Dum during the month of May. In fact only three squalls over Alipore and seven over Dum Dum have been recorded in the month of March during the study period. Most of the squalls have occurred during the month of April and May over both Alipore and Dum Dum. It can be seen from the Tables 2(a-c) that weather remains comfortable for longer period over Kolkata and neighbourhood after nor'wester activity during the month of March and April averaging 22 and 11 hours respectively. During the month of May

weather is comfortable over Kolkata and neighbourhood after nor'wester activity but for a brief period. As we approach towards the end of the month of May nor'wester activity does bring relief to the people of Kolkata and neighbourhood but for very short period only. The study reveals that nor'wester activity over Kolkata give some relief to the people during hot and sultry summer months. Depending on the results of the study it is possible to include comfortability factor in the local forecast for Kolkata and neighbourhood in the event of nor'wester activity.

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