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ON SOME ASPECTS OF BOUNDARY LAYER OVER MADRAS AIRPORT

1. Atmospheric stability depends on the temperature variation with height. Air pollution potential, the inability or otherwise of the atmosphere to disperse and dilute pollutants, depends on mixing depth and mean layer wind speed. The elevated inversion acts as a lid and limits the vertical mixing of pollutants. High pollution potential is related to low ventilation coefficient which is the product of mixing depth and mean layer wind speed. Forecast of high pollution potential may help Regulatory agencies to take suitable remedial measures like scheduling the emission of harmful pollutants (*i.e.* the air quality management) or taking policy decision on the grant of license to factories etc. The most commonly used Gaussian plume model and Gradient - transport (*K*) model requires the stability of the atmosphere for estimating other parameters in the model (WMO, 1982). Also, the power law coefficients to account for variation of wind with height within the boundary layer are estimated for different stability conditions. Pasquill's stability classes as modified by Turner (1964) have been used in this note to workout the stability of the atmosphere over Madras. The mixing height has been computed employing the Holzworth (1967) method.

2. The synoptic and auxiliary synoptic hours surface observations (0000,0300,0600,.......,2100 UTC) recorded by the Meenambakkam Airport meteorological office, Madras for the period January, February (winter season) and October to December (northeast monsoon season) 1984 to 1988 have been used. The RS/RW data (0000 and 1200 UTC) upto 700 hPa of the same period also have been used to workout the morning and evening mixing heights.

The above data set were obtained from the National Data Centre, Pune and the missing data records were collected from the records maintained at the climatological sections of the Regional Meteorological Centre, Madras. The temperature and wind at 0.3, 0.6, 0.9, 1.5 and 2.1 km were extracted from the records maintained at RS/RW unit, Madras.

3. Turner's method of modified Pasquill's stability categories proposes the following symbols.

A- Extremely unstable, B - Unstable ,

C - Slightly unstable , D- Neutral ,

E- Slightly stable , F - Stable ,

G - Extremely stable.

This scheme was used for the Indian stations by Padmanabhamurthy and Gupta (1982), Maske (1982). The method utilises net radiation index (NR) derived from solar altitude, cloud cover and surface wind speed.

TABLE 1

Diurnal variation of stability (percentage) frequencies for the month of January 1984-88 over Madras

Hours (UTC)	Stability categories A	B	C	A+B+C	D	E	F	G	E+F+G
00	0	0	77	77	5	1	17	0	18
03	12	49	28	89	11	0	0	0	0
06	31	19	43	93	7	0	0	0	0
09	0	51	7	58	42	0	0	0	0
12	0	0	10	10	71	12	7	0	19
15	0	0	0	0	7	7	24	62	93
18	0	0	0	0	6	4	13	77	94
21	0	0	0	0	7	1	14	78	93

3.1(a). The diurnal variation of the stability classes for the month of January, a typical representative month of winter is given in Table 1. The unstable categories are confined just prior to and after sunrise and the percentage frequency generally increases with solar altitude with its maxima around 0600 UTC when the sun is almost overhead and thereafter the frequency decreases to zero after sunset. Similarly, the stability categories are observed just before sunset, continued throughout night and is totally absent after sunrise. The neutral class is seen throughout the day (though of low frequency) due to the presence of scattered low clouds and its percentage frequency has a maximum at 1200 UTC when the sky is almost overcast on maximum number of days.

3.1 (b). Table 2 lists the diurnal variation of percentage frequencies of the stability classes for the month of November representing post monsoon season (also called northeast monsoon season). The frequencies of neutral class are well distributed thro' the day and night, comparatively on the higher side than that of winter season due to the persistent, almost overcast sky during the northeast monsoon season. Also, the frequencies of the stable categories during night are of lower magnitude than that in winter, as the total cloud cover during the night time is more than that of winter suggesting maximum frequency was restricted to either neutral(D) or slightly stable (E) conditions only. The inconsistent unstable classes frequencies (relatively low in comparison to January and February) between October, November and December could be due to the varying amount of cloud dissipation during these months after the early morning precipitation which is quite common during northeast monsoon season. The monthwise percentage frequencies of stability classes are summarised in Table 3 which may be of some use to environmental engineers for pollution monitoring and control.

3.2. Mixing height is the height above the surface upto which vertical mixing can take place or the height below the base of elevated inversion. The morning and afternoon mixing heights have been computed based on the method

TABLE 2

Diurnal variation of stability (percentage) frequencies for the month of November 1984-1988 over Madras

Hours (UTC)	Stability categories								
	A	B	C	A+B+C	D	E	F	G	E+F+G
00	0	0	41	41	30	1	28	0	29
03	4	38	23	65	35	0	0	0	0
06	15	26	33	74	26	0	0	0	0
09	0	26	10	36	64	0	0	0	0
12	0	0	13	13	55	19	13	0	32
15	0	0	0	0	24	9	26	41	76
18	0	0	0	0	16	10	32	42	84
21	0	0	0	0	19	5	33	43	81

TABLE 4

Diurnal variation of mixing heights for the months of January, February &October - December 1984-1988 over Madras

Months	Mixing Heights (m)	
	Morning	Evening
January	463	729
February	666	900
Jan - Feb	560	810
October	1420	1710
November	1360	1620
December	973	1121
Oct- Dec	1250	1480

suggested by Holzworth (loc. cit.) and they are presented in Table 4. Days of precipitation have been excluded. In order to compute the morning mixing height, 3°C was added to the 0000 UTC surface temperature to absolve the urban heat island effect (Jayanthi, 1991). The mean morning mixing height works out to be 560 m for January - February and 810 m for October - December. The low value of January - February mixing depth might be due to high incidence of stable atmosphere (see column 7 to 10 of Table 1 & 2) and/or elevated inversion frequency (of course the same could not be detected from the conventional RS/RW data at standard pressure levels and at 50 hPa intervals). The mean afternoon mixing height for January - February is 1250 and 1480 m for October - December.

3.3. The percentage frequencies of surface inversion at 0000 UTC based on the available temperature profile at 0.3, 0.6, 0.9 and 1.5 km have been worked out. No ground based inversion was observed at 1200 UTC during the period under study. The above results are agreeing reasonably well with the published records of India Meteorological Department (IMD, 1983) based on special low level ascent data (Table 5). The ground based inversion frequency is more during winter season than the northeast monsoon season. The depth of inversion is mostly restricted to 300 m above ground. The strength of inversion is defined as $\partial\theta_v / \partial_z$ where θ_v is the virtual potential temperature. The maximum

TABLE 3

Percentage stability frequencies for the months of January, February and October- December 1984-88

Months	Stability categories						
	A	B	C	D	E	F	G
January	5	15	21	20	3	9	27
February	7	18	19	19	3	8	26
January- February	6	17	20	19	3	9	26
October	·4	14	16	24	6	18	18
November	3	11	15	34	5	16	16
December	4	12	18	28	5	12	21
October-December	4	13	17	28	5	15	18

TABLE 5

Percentage frequencies of thickness of surface inversion layer over Madras, January-February and October-December, 1984 to 1988

Height (m)	Months				
	January	February	October	November	December
0 - 300	25.8 (24)	26.2 (24)	7.2 (6)	4.2 (4)	11.3 (12)
301-600	5.2 (3)	5.7 (5)	4.7 (4)	3.5 (3)	6.7 (6)
601-900	0.0 (0)	1.2 (0)	0.0 (0)	0.0 (0)	1.3 (0)
901-1500	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)

Figures furnished in brackets are extracted from IMD (1983)

strength of inversion is 4.7 × 10 °K/ m during winter and 2.4 × 10 °K/m during northeast monsoon season. The percentage frequency of elevated inversions could not be computed from this data set. The high frequency of ground based nocturnal inversions and Pasquill's stable conditions of the atmosphere could be the cause for high concentration of pollution in the lowest part of the atmosphere reducing visibility in the morning hours through the formation of fog and mist over Madras airport during January-February.

4. The following results are obtained from this study.

(*i*) The high frequency of stable conditions occurs just before sunset and continues throughout the night during January and February (a period of relatively less number of rainy days) while the same condition with marginally low frequencies is observed during October to December (having more number of rainy days).

(*ii*) The neutral stability conditions are observed during day and night for all the months with its frequency maxima by afternoon just prior to sunset. The percentage frequency is evenly distributed during northeast monsoon season (due to persistent, almost overcast sky condition) in comparison to winter.

(*iii*) The unstable conditions are completely absent after sunset and 2 to 3 hours prior to sunrise. The frequency increases with solar altitude and the maxima is observed around noon.

(*iv*) Within the months, unstable category frequencies have large variation during morning hours of northeast monsoon season due to the varying nature of early morning precipitation and dissipation of clouds.

(*v*) The nocturnal surface inversion has high frequency during January, February and is restricted to 300 m above ground with the maximum strength of inversion to 4.7×10 °K/m during January.

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