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A case study of poor visibility over Bombay airport

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ABSTRACT. A case study of poor visibility, on the morning of 4 March 1974 over Bombay Airport and its surroundings, was made with reference to the moisture and pollution content in the atmosphere. It was observed that : (*i*) high relative humidity alone was not sufficient to cause poor visibility, (*ii*) a steep and shallow inversion helped in causing poor visibility and (*iii*) the visibility was inversely proportional to the concentration of pollutants.

1. Introduction

Rangarajan (1952), Viswanathan and Faria (1963) studied fog over Bombay by mainly considering humidity. They did not consider pollution in their studies. Jayanthi (1973) computed an air pollution potential coefficient for inland and coastal stations, but did not correlate it with visibility.

Bombay Airport is situated within a few kilometres to the westnorthwest of the thick industrial area of Kurla and Chembur. On 4 March 1974 the visibility recorded was as low as 50 m at 0200 GMT. The air traffic at Bombay Airport was seriously affected by poor visibility. Departures and arrivals of aircraft belonging to Indian Airlines, Air India and other foreign airlines were delayed by three to eight hours. An attempt has been made here to explain the conditions for this case of poor visibility by tracing the trajectory of the pollutants and by computing the pollution content.

2. Data

Surface and upper air data from 1800 GMT of 2 March to 0400 GMT of 3 March, and for a similar period for 3/4 and 4/5 March 1974 were considered. Surface wind data were taken from Dines PT anemograph and upper winds were taken from the radiosonde observations of 00 GMT on respective days.

3. Discussion of results

Fig. 1 provides a graph of relative humidity and visibility on 2/3 , 3/4 and 4/5 March 1974. It is observed that the minimum visibility of 50 m was recorded at 0200 GMT on 4 March, but the visibility reported at the same time on the previous and the following days was 1500 and 1000 m respectively. The relative humidity recorded was 97, 72 and 88 per cent respectively.

It is of interest to note that at 1900 GMT of 2 March the visibility was 3 km with 73 per cent relative humidity ; at 23 GMT of 3 March visibility was 2 km with 97 per cent relative humidity; but at 0100 GMT of 5 March the visibility was 3 km with 90 per cent relative humidity. On 4th the relative humidity was 97 per cent at 00, 02 and 03 GMT , while the visibility was 500, 50 and 1000 m respectively. On 5th, 90 per cent relative humidity was recorded at 00 and 01 GMT and the visibility was 5 and 3 km respectively.

It may be inferred from the above that the variation in visibility on these days over Bombay Airport was not related to relative humidity alone. Besides humidity, there was an additional factor which caused poor visibility. This additional factor was pollution coming from the nearby industrial area. The pollution content of the atmosphere depends upon the prevailing surface and upper winds and the inversion.

It may be observed from 00 GMT ascents on 3 to 5 March that the inversion extended from ground level. The details regarding the inversion on these days are given in Table 1.

We observe from Table 1 that the thickness of the inversion on 4th is least, and is of the order of 44 mb. The inversion on this day was steeper than that on the 3rd or 5th, *viz.*, 1.95 °C/10 mb. On 3rd, surface winds between 20 and 22 GMT were southwesterly or

the low level system was already existing upto 600 mb. Thus the two systems behaved as a single one in the vertical with a large westward tilt. Further, in the present case, the low level system itself was not seen to intensify due to paucity of data but the resultant precipitation did corroborate to the magnitude of the intensification.

Even though Rao *et al.* (1970) have stated that the Pir Panchal Range in J & K acts as barrier preventing the monsoon rainfall reaching the northern half of J & K, the present study reveals that under favourable conditions, monsoon currents can deeply penetrate into north J & K beyond Pir Panchal causing heavy rains.

Ananthakrishnan and Bhatia (1960) have referred to cases of floods in Kashmir in association with monsoon depressions recurving northeastwards from Rajasthan. The present study further reveals that even in absence of a monsoon depression, devastating floods can occur in J & K as in the present case.

4. Conclusion

This study reveals that devastating floods can occur in J & K during the monsoon season, even in the absence of monsoon depressions and western disturbances. The necessary conditions for such a flood are : (*i*) some low level agency such as a cyclonic circulation to make possible penetration of monsoon air deep into J & K and (*ii*) a high level system resulting in pronounced high level divergence.

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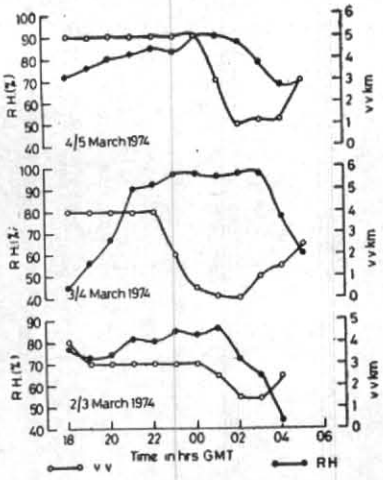

Fig. 1. Relative humidity (R. H. in %) and visibility (VV) at Bombay Airport between 2 & 5 March 1974

westsouthwesterly, which brought moisture from the adjacent ocean and increased relative humidity from 67 to 92 per cent. The pollution load of the atmosphere was almost stagnant around the source of the pollution, which was at a distance of a few kilometres fom the Airport. Thus, within a period of 2 to 3 hours when the surface winds were southwesterly or westsouthwesterly the polluted air was mixed with moist air from the sea. This moved eastwards and mixed further with pollutants existing over Bombay Airport and its neighbourhood. The effect of an interaction of pollution and moisture was accentuated by the presence of a steep and shallow inversion in the atmosphere. This resulted in very poor visibility of 50 m at 02 GMT on 4 March 1974.

To get an idea of the extent of pollution around Bombay Airport trajectory of a parcel of air pollutants was drawn for these days.

Since wind observations at other points were not available and the area under study being small, while computing the trajectory, the surface wind recorded at Santacruz was taken as representative of the prevailing wind at various points along the trajectory. The thick industrial area of Kurla and Chembur has been taken as the source of pollution (B) which is about 4 km eastsoutheast of the Airport. Figs. 2 (a,b and c) show the trajectories of pollutants drawn from the source (B) on these days for the period 18 to 02 GMT.

It is seen from Figs. 2 that the pollutants remained within a distance of 23, 7.5 and 46 km from the source (B) and within a distance of 20, 3.5 and 46 km from the Airport on these days, respectively. On the 4th, in particular, the pollutants remained concentrated within a distance of 3.5 km from the

TABLE 1

The inversion data for 2-5 March 1974

	00 GMT of 3 March 1974		00 GMT of 4 March 1974		00 GMT of 5 March 1974	
	TT (°C)	PPP (mb)	TT (°C)	PPP (mb)	TT (°C)	PPP (mb)
Base (ground level)	20·2	1011	23·0	1010	20·2	1007
Top	32·4	947	31·6	966	28·6	920
Thickness of inversion	64 mb		44 mb		87 mb	
Lapse rate (Negative) °C/10 mb	1·90°		1·95°		0·96°	

TABLE 2

The values of P (concentration of pollutants) during 3-5 March 1974

Date	Concentration of pollutants
3 March 1974	0·03 K
4 March 1974	0·47 K
5 March 1974	0·10 K

Airport resulting in poor visibility over Bombay Airport and neighbourhood.

In order to compute the concentration of pollutants it is considered that (*i*) visibility (V in m) is directly proportional to the thickness of inversion (T_h in mb), (*ii*) inversely proportional to concentration (P) of pollutants, (*iii*) inversely proportional to relative humidity (R_H in per cent), and (*iv*) inversely proportional to negative lapse rate (L_r in °C/10 mb),

$$i.e., \quad V \propto T_h,\ V \propto \frac{1}{P},\ V \propto \frac{1}{R_H},\ V \propto 1/L_r$$

$$\text{or} \qquad V = \frac{K \times T_h}{P \times R_H \times L_r}$$

$$\therefore \qquad P = \frac{K \times T_h}{V \times R_H \times L_r}$$

where K is the constant of proportionality. From the above formula the values of P are computed valid for 02 GMT of 3, 4 and 5 March 1974 and are presented in Table 2.

It can be seen from Table 2 that the concentration of pollutants on 3rd and 5th was less compared to the concentration of pollutants on 4th, the day on which the concentration was very high and the visibility was very poor.

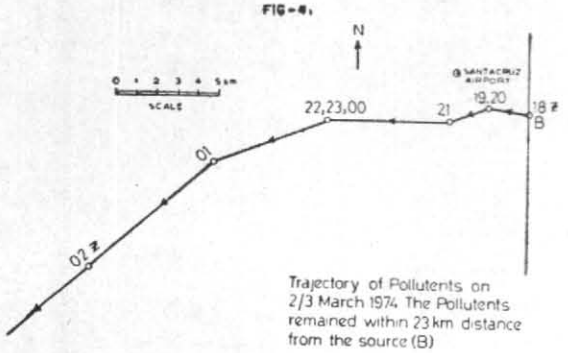

Fig. 2 (a)

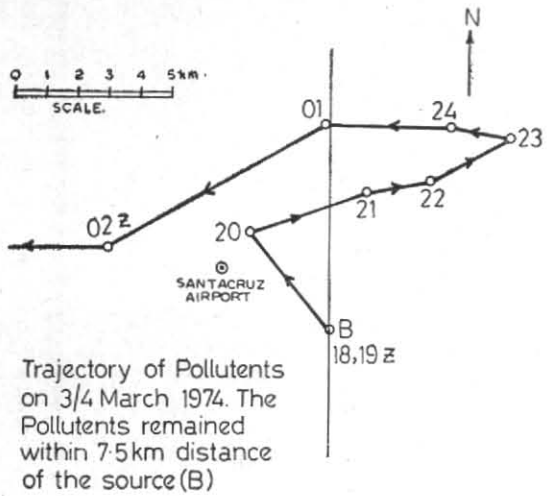

Fig. 2 (b)

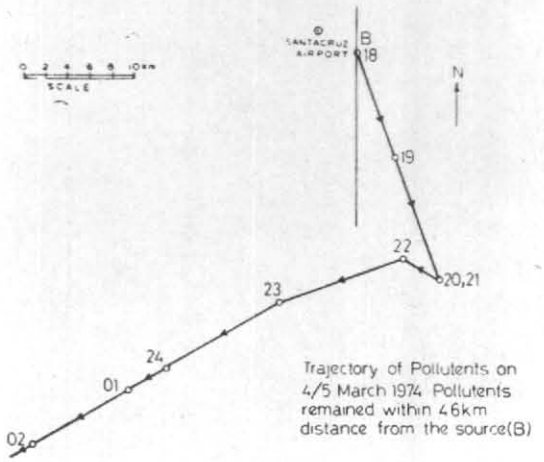

Fig. 2 (c)

4. Conclusions

Thus it can be inferred from the above discussion that —

(*i*) High relative humidity alone is not sufficient to cause poor visibility at Bombay Airport.

(*ii*) A steep and shallow inversion helps in causing poor visibility.

(*iii*) The higher concentration of pollutants over the Airport helps in reduction of visibility.

The westerly winds during the night of the 3rd resulted in interaction of pollution and moisture. The effect of the interaction was accentuated by the presence of a steep and shallow inversion resulting in very poor visibility.

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