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Effective pollution potential over ten Indian stations*

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ABSTRACT. An effective pollution potential index is suggested as a measure of air pollution. Effective pollution potential indices for ten seected stations in India are obtained for each month, season and year. It is concluded that high pollution potential exists over the stations in different months, which necessitates taking precautionry measures.

1. Introduction

The presence of air pollutants in concentrations sufficient to affect man's health and welfare depends on the balance between the production of pollutants and dispersion. The meteorological conditions prevailing play an important role in the dispersion. The principal element that needs consideration is vertical temeperature gradient. In most cases, adverse conditions normally result from a combination of low wind speed and temperature inversion associated with high rate of emission of pollutants.

As the data on pollution concentration are not available, it was not possible to derive a single convenient pollution index with these three parameters mentioned above. Alternatively, meteorological stress indices, which could be taken as a measure of the pollution concentrations are necessary (Lowry and Reiquam 1968). In the present study, the author obtained a measure of pollution potential index using the vertical temperature distribution for ten stations situated in different geographic areas.

2. Data and Analysis

Monthly mean (00 and 12 GMT observations) values of vertical temperature (from surface to 300mb level) for ten radiosonde stations in India, for the period 1967-1971 are used.

If the actual lapse rate is less than the dry adiabatic, turbulence is decreased. Stable air where temperature increases with height is condueive for formation of pollution layer. As the height of inversion base affects smog density ordinarily, the lower the base, the worse the smog. It is seen (Hirst *et al.* 1967) that high concentration of pollutants corresponds to strong inversion to get an amplified and uniform temperature difference from inversion layer to the surface, the vertical temperature profile is first subtracted from the standard atmospheric temperature profile and then the difference is obtained. As all the stations under consideration lie south of Lat. 40°N the observed temperature profiles are subtracted from U.S. standard atmospheric profile at Lat. 40°N.

The temperature departures are obtained as follows :

$$T_{D,p} = T_{0,p} - T_{c,p} \qquad (1)$$

where,

$T_{D,p}$=temperature departure at a height p mb,

$T_{0,p}$=observed mean temperature at a height p mb,

and $T_{c,p}$=temperature obtained from U.S. standard atmosphere at a height p mb.

The temperature departures are obtained from surface to 300-mb level for ten stations, for twelve months, three seasons and annual value. The vertical profiles of temperature departure (T_D) for three seasons and annual are shown in Fig. 2.

It is seen from Fig. 2 that the effect of pollutants on temperature is less as we go up from 850-mb level, *i.e.*, the effect of pollutants will increase as p-the inversion layer height lies below 850-mb level. The layer at p will act as a barrier to upward motion of warm air from surface and down coming radiation from above and by which the discomfort will increase. Keeping these points in view, the effective pollution potential is formulated as follows.

Increase in effective pollution potential corresponds to (i) the increase in the thickness between 850-mb level and inversion point p downwards,

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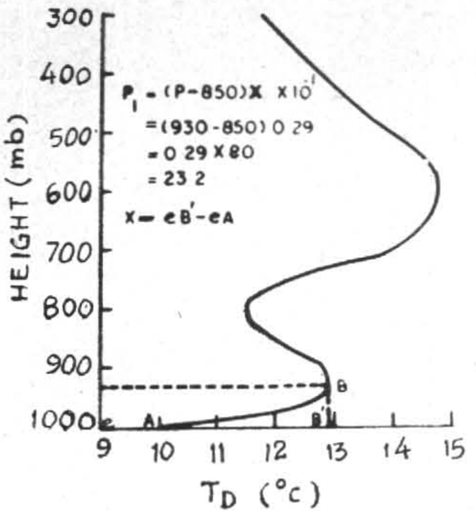

Fig. 1
Explanation of X, P and, P_I

TABLE 1

Pollution potential	P_I	Effect on population	
Nil	$\leqslant 0$	Nil	
Slight	0–15	20% will be affected	
Moderate	15–30	*50%	Do.
Heavy	30–45	*90%	Do.
Very heavy	$\geqslant 45$	*All	Do.

*Necessary care to be taken for minimising the effect

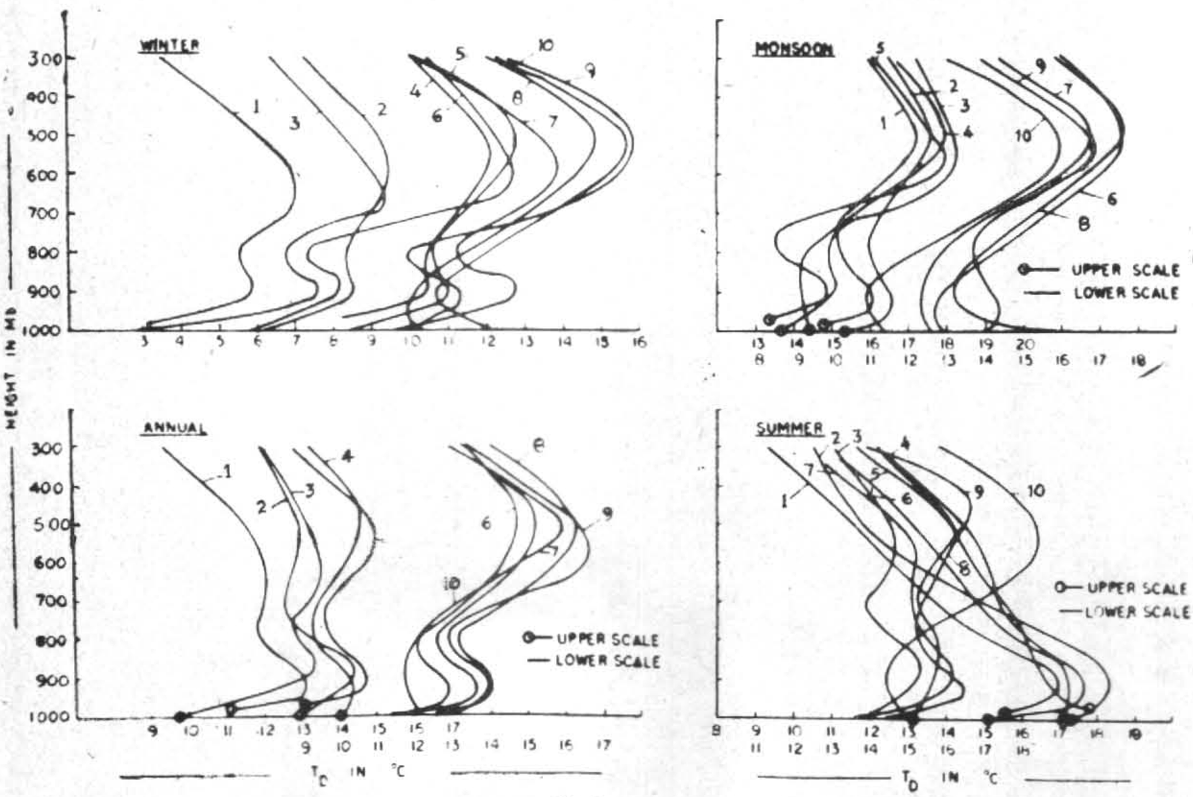

Fig. 2

Variation of temperature departure (T_D) with height for annual and three seasons

1. New Delhi, 2. Jodhpur, 3. Lucknow, 4. Ahmedabad, 5. Nagpur,

6. Calcutta, 7. Bombay, 8. Visakhapatnam, 9. Madras, 10. Trivandrum.

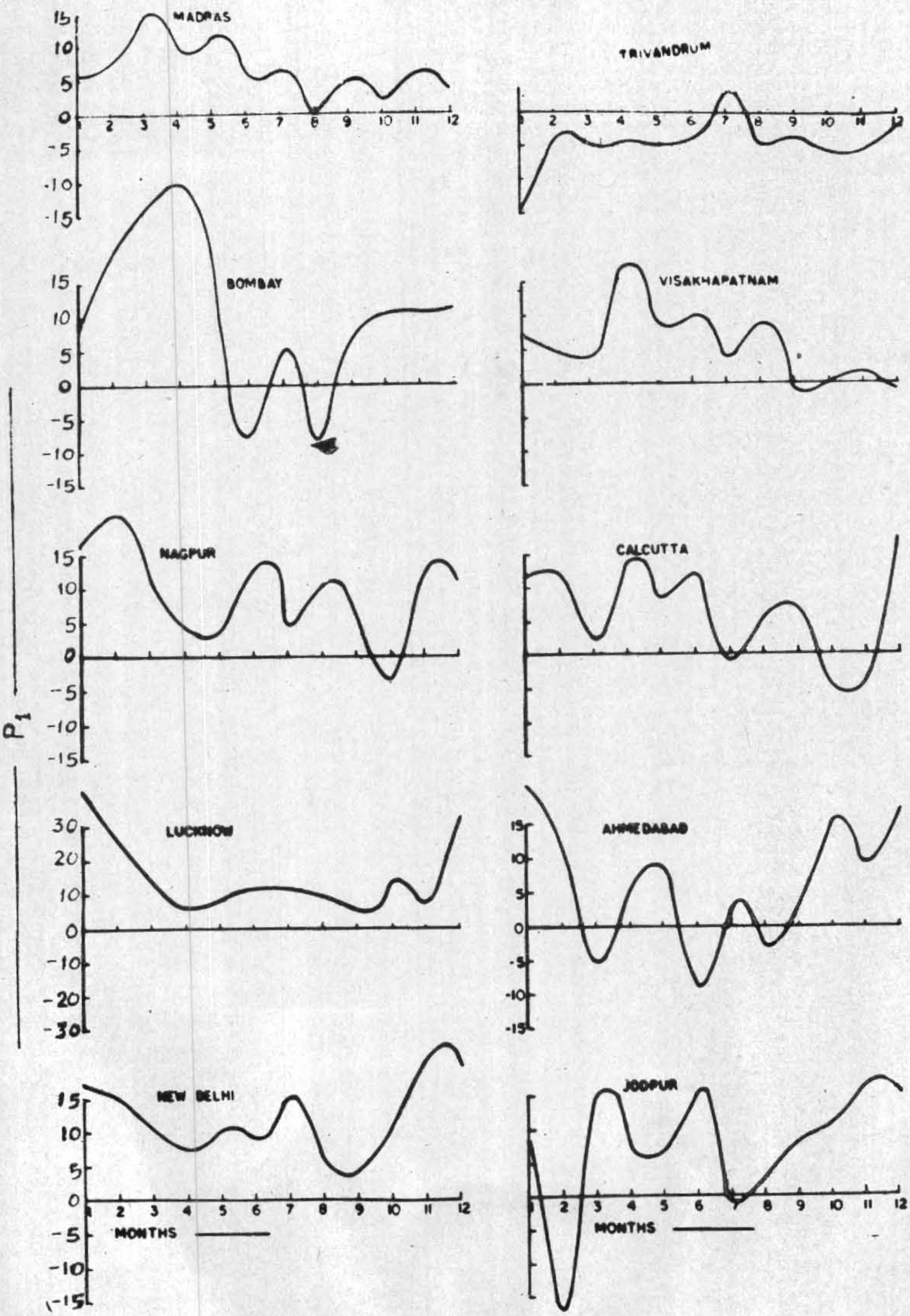

Fig. 3
V ariation of P_I with months

TABLE 2

Station	Monthly pollution potential index			
	Heavy	Moderate	Slight	Nil
New Delhi	—	Nov to Feb, Jul	Mar to Jun Aug to Oct	—
Jodhpur	—	Nov, Dec, Jun	Jan, Mar to May, Aug to Oct	Feb, Jul
Lucknow	Dec, Jan	Feb	Mar to Nov	—
Ahmedabad	—	Oct, Dec, Jan	Feb, Apr to May, Jul to Sep, Nov	Mar, Jun
Nagpur	—	Jan, Feb	Mar to Sep, Nov, Dec	Oct
Calcutta	—	Dec	Jan, to Jun Aug to Sep	Jul, Oct, Nov
Bombay	—	Feb to Apr	Jan, May, Jul, Sep to Dec	Jun, Aug
Visakha-patnam	—	Apr	Jan to Mar May to Aug and Nov	Sep, Oct, Dec
Madras	—	—	Jan to Jul, Sep to Dec	Aug
Trivandrum	—	—	Jul	Jan to Jun, Aug to Dec

and (*ii*) positive increase in the separation between inversion point value ($T_{D,i}$) and surface value ($T_{D,s}$); positive if $T_{D,i} > T_{D,s}$ where i and s respectively stand for inversion point and surface value of T_D.

Therefore, an effective pollution potential index (P_I) is

$$P_I = \frac{(P-850)\, X}{10} \quad (2)$$

where $X = T_{D,i} - T_{D,s}$ in °C

(In which $T_{D,i}$ and $T_{D,s}$ are respectively the temperature departure values at inversion point and surface which respectively corresponds to B′ and A in Fig. 1)

p=height of the inversion layer, in mb. (In Fig. 1 it corresponds to the height of B, given as p).

However, utilizing the results obtained using Eq. (2) for ten stations and some of the observed facts at these stations, an arbitrary scale has been adopted in Table 1 for discussion of P_I values.

3. Discussion

Fig. 2 shows the pattern of variation of temperature departure (T_D) from surface to 300 mb for 10 stations (for the present study the vertical T_D profile from surface to first inversion point is only considered). From annual profile it is seen that Lucknow and Bombay are seen with more pronounced variations in T_D at inland and coastal stations respectively and next in decreasing order come New Delhi, Nagpur, Jodhpur, Ahmedabad in case of inland stations and Calcutta, Visakhapatnam, Madras, Trivandrum in case of coastal stations. In winter more pronounced variations in T_D are seen over inland stations. In summer more pronounced variations in T_D are seen at coastal stations, contrary to what is observed in winter. In monsoon, negligible variation in T_D are seen at all the stations, which is expected because of onset of monsoon over the country and also precipitation washes out pollutants in the atmosphere.

Fig. 3 depicts the variation of the monthly pollution potential index (P_I) and Table 2 summarises the results.

4. Conclusions

1. Generally maximum effect of pollutants are observed over inland stations in winter and over coastal stations in summer.

2. Out of five stations considered, Lucknow has high effective pollution potential and New Delhi, Nagpur, Ahmedabad and Jodhpur follow.

3. Similarly out of five coastal stations under consideration, Bombay has high effective pollution potential and Calcutta, Madras, Visakhapatnam and Trivandrum follow.

4. It appears from this study that it may necessitate taking precautionary measures over the stations in the months indicated against them, to reduce the harmful effects of air pollution — New Delhi (Nov to Feb and Jul), Lucknow (Dec to Feb), Ahmedabad (Dec to Jan), Nagpur (Jan and Feb), Calcutta (Dec), Bombay (Feb to Apr) and Visakhapatnam (Apr).

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