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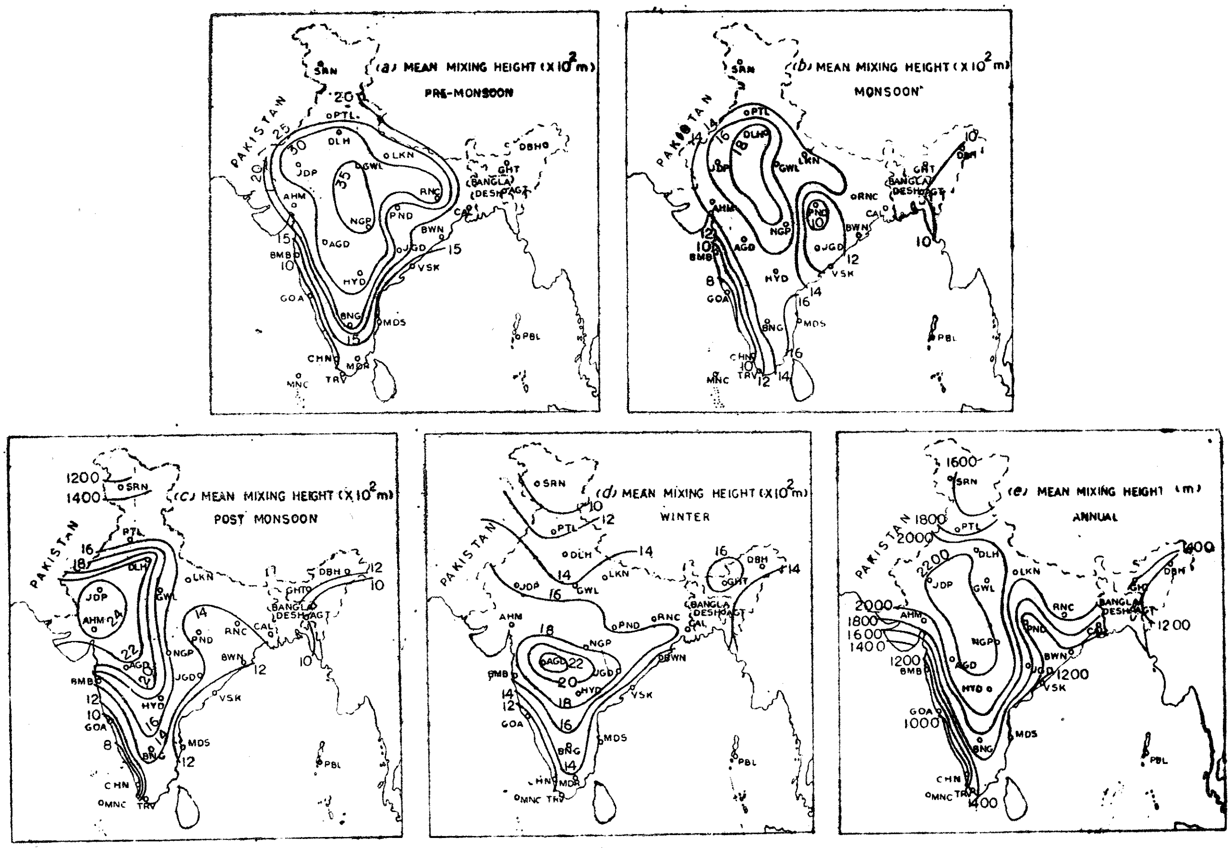
# METEOROLOGICAL POTENTIAL FOR URBAN AIR POLLUTION IN INDIA

Apprehensions have been prevailing in India that, largely because of air pollution, living in urban complexes is becoming more unhealthy due to rapid industrialization and consequent urbanization. Interest has been evinced by environmentalists to project pollutant concentrations and compare with different cities of other parts of the world. Theoretically concentration attainable can be obtained by mathematical models from a knowledge of plant characteristics, meteorology and the diffusion parameters. Though this is economical, often all the components of the model are not readily available especially diffusion parameters. Yet, we can have a foresight into some broad aspects of atmospheric dispersion by considering the meteorological potential for urban air pollution throughout the country.

2. Mixing height is the surface bounded layer of the atmosphere through which relatively vigorous vertical mixing occurs. At night in rural areas they are absent, being replaced by ground based temperature inversions in which vertical mixing is minimal. However, due to heat island effect urban areas exhibit mixing heights. The hight of the mixing layer is important in many




Figs. 1 (a-e). Mean mixing height in (a) pre monsoon season, (b) Mean mixing heights in monsoon season, (c) Mean mixing height in post-monsoon. season, (d) Mean mixing height in winter season and (e) Annual mean mixing height (m)

considerations of dispersion. Mixing heights over urban areas vary diurnally by more than two orders of magnitude.

Mixing heights rarely are measured directly but can be determined from the vertical temperature distribution with the assumption that in a thoroughly mixed unsaturated atmosphere the temperature lapse rate is dry adiabatic. The morning (urban) mixing height is the height above ground level where the dry adiabatic extension of the morning minimum surface temperature *plus* 5 deg. C intersects the vertical temperature profile near sunrise that morning (00 GMT). The '*plus* 5 deg. C' roughly allows for average effects of the urban heat island of medium and large cities. To obtain the afternoon mixing height, maximum surface temperature itself is used (Holzworth 1970).

Low mixing heights with strong winds have the same effect on pollution transport as light winds associated with larger mixing heights. Therefore, in air pollution potential studies, the ventilation coefficient — a product of mixing height and average wind speed in the layer— is generally employed.

In the present paper maximum mixing heights are computed from the daily radiosonde data at 00 GMT and maximum temperature. Winds in the mixing layer are the average pilot balloon winds and surface winds corresponding to 12 GMT. Data of 27 radiosonde stations are utilised in the present study.

3. Mean mixing heights (maximum) in pre-monsoon, monsoon, post-monsoon, winter seasons and annual are presented in Figs. 1 (a-e) respectively. Mixing heights are highest in pre-monsoon and lowest in monsoon season. They increased in the post-monsoon season to lower again in winter but winter magnitudes are still higher than monsoon season. The zone of high mixing heights lies in the central parts of northern India except in winter when it shifted to northern parts of Deccan plateau. The annual distribution indicates a zone of large mixing heights in the central parts of the country and low values on the west coast.

Mean annual wind speeds (Table 1) are low in the extreme north, in the east, southwestern Peninsula and central parts of the country.

Ventilation coefficients corresponding to the mixing height maps are given in Table 1. They are highest in pre-monsoon and lowest in winter. West coast, northern most parts of north India and eastern India have low ventilation coefficients. The annual ventilation coefficients also show low values in the eastern India and west coast. High values are found in parts of Bihar, Madhya Pradesh and Haryana on an annual basis.

**TABLE 1**

**Mean ventilation coefficients in different seasons**

| Station | Pre-monsoon | Monsoon | Post-monsoon | Winter | Annual | Annual wind speed (m/s) |
|---|---|---|---|---|---|---|
| Srinagar | 6,408 | 2,856 | 1,760 | 1,008 | 9,696 | 2 |
| Patiala | 16,640 | 4,699 | 5,016 | 5,200 | 18,268 | 4 |
| Delhi | 20,032 | 11,036 | 11,712 | 5,808 | 11,813 | 5 |
| Jodhpur | 16,960 | 11,592 | 10,080 | 6,240 | 10,431 | 5 |
| Lucknow | 18,360 | 6,231 | 5,106 | 4,385 | 10,300 | 6 |
| Ahmedabad | 15,198 | 5,200 | 7,772 | 6,438 | 9,130 | 5 |
| Ranchi | 19,380 | 6,355 | 5,400 | 10,780 | 15,626 | 6 |
| Gauhati | 6,283 | 4,212 | 2,200 | 3,520 | 5,478 | 4 |
| Dibrugarh | 4,235 | 3,192 | 2,484 | 3,540 | 2,023 | 3 |
| Agartala | 10,076 | 4,230 | 1,152 | 4,480 | 5,346 | 4 |
| Calcutta | 8,118 | 7,410 | 4,340 | 5,066 | 7,039 | 5 |
| Bhubaneswar | 14,268 | 7,704 | 7,410 | 9,100 | 9,365 | 7 |
| Jogdalpur | 17,820 | — | 6,000 | 3,956 | 7,198 | 4 |
| Nagpur | 13,824 | 7,370 | 6,084 | 11,628 | 11,303 | 5 |
| Aurangabad | 17,850 | 11,320 | 13,110 | 10,810 | 17,133 | 6 |
| Bombay | 5,481 | 8,239 | 5,445 | 6,192 | 7,222 | 6 |
| Hyderabad | 15,170 | 10,434 | 9,450 | 6,125 | 10,885 | 5 |
| Visakhapatnam | 4,620 | 5,936 | 7,424 | 7,125 | 7,057 | 6 |
| Goa | 3,550 | 3,680 | 4,590 | 4,230 | 5,701 | 6 |
| Bangalore | 12,150 | 10,005 | 6,640 | 6,450 | 9,512 | 6 |
| Madras | 7,840 | 12,960 | 9,261 | 6,860 | 8,878 | 6 |
| Cochin | 4,423 | 8,436 | 3,096 | 5,676 | 5,881 | 5 |
| Trivandrum | 6,721 | 13,516 | 6,768 | 5,775 | 10,351 | 6 |
| Minicoy | 3,876 | 9,040 | 4,141 | 4,104 | 5,320 | 6 |
| Port Blair | 3,564 | 4,644 | 2,210 | 6,129 | 4,873 | 6 |
| Gwalior | 20,650 | 7,257 | 7,410 | 5,244 | 10,285 | 5 |
| Pendra | — | 4,849 | 4,200 | 8,460 | 8,133 | 6 |

4. West coast south of Bombay to Cochin and the entire eastern India have very low ventilation coefficients indicating that the pollution potential is high.

**Reference**

Holzworth, G.C., 1970, 'Meteorological Potential for Urban Air Pollution in the Contiguous United States', Paper presented at the Second International Clean Air Congress, Washington D.C., 6-11 December.

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