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DIURNAL AND SEASONAL VARIATION OF THE THERMAL STABILITY OF THE ATMOSPHERE CLOSE TO THE SURFACE AT POONA IN RELATION TO AIR POLLUTION*

1. The vertical transport and diffusion of pollutants discharged into the lower layer of the atmosphere close to the ground from industrial complexes, depend on the thermal stability of this layer. A study of the diurnal and seasonal variations in the thermal stratification of this layer is therefore of importanace in problems related to air pollution. A restricted study of this type has been made for Poona by making use of the temperature data recorded at two different levels and the results are briefly presented in this contribution.

2. For a period of several years in the past, two sets of self-recording thermographs and hygrographs were operating at Poona in the premises of the Meteorological Office — one set inside a Stevenson Screen at the ground level and another inside a screen installed on the top of the office tower at an elevation of 120 ft above the ground. Although the records and tabulations at the two sites were maintained for some three decades, no comparative study of the data appears to have been made. It was, therefore, considered worthwhile to examine the data for a few selected years with the specific purpose of understanding the diurnal and seasonal variations in the thermal stability of the atmospheric column between the two levels of observation. The results discussed below are based on the records for the years 1949, 1954, 1957 and 1960 selected at random. Although the observational data for all the months have been studied the data for the four typical months January, April, July and October only are presented here.

3. The mean hourly differences of temperature between the thermographs at the ground level (E) and that at the top of the tower (T) for the four months are presented graphically in Fig. 1 in which the times of sunrise and sunset are also indicated.

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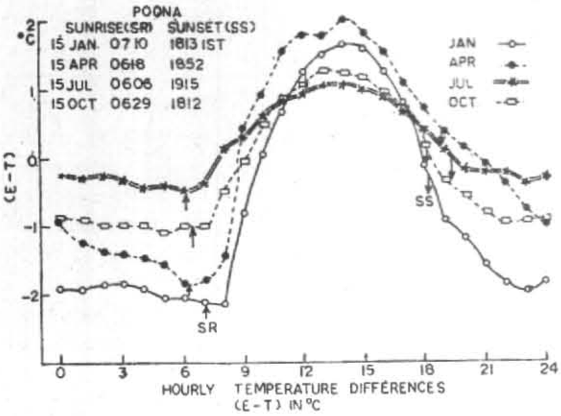

Fig. 1. Hourly temperature differences (E-T) in °C

January — In this month which is typical of winter conditions, the day-time lapse rate between the two levels changes over to an inversion between 1700 and 1800 hr in the evening. The inversion steepens at first rapidly and later gradually till early morning when the air temperature at the top of the tower exceeds than inside the screen at the ground level by a little over 2°C. The inversion between the two levels persists for about 2 hours after sunrise. It breaks up between 09 and 10 hr. In January, therefore, the low level inversion persists for about 17 hours.

April — This is the typical summer month at Poona. In this month the air near the ground becomes cooler than at the top of the tower after 2000 hr at night. Thereafter the difference of temperature steadily increases reaching 1·8°C in the early morning. As in January, the air at the higher level continues to be warmer than that near the ground level for a couple of hours after sunrise. The change over from night time inversion to day time lapse rate occurs between 08 and 09 hr. Thus in April, the low level inversion is present for 12 hours as against 17 hours in January.

July — This is the typical monsoon month with cloudy skies and steady westerly winds. The observational data for all the years show that a feeble nocturnal inversion between the ground level and the tower top exists even in this month. The maximum difference of temperature between the two levels is 0·4°C towards early morning. One may be inclined to be somewhat sceptical of this result since it would be expected that the cloudy skies and windy conditions would not allow a low level inversion to develop. However, the observational data are contrary to this expectation. It would be of interest to confirm or disprove this result by an independent set of observations with more sophisticated temperature recording devices installed at the two locations for one or two monsoon seasons. However, boundary layer studies of wind and temperature in the first 30 m of the atmosphere carried out in the U.S.A. with sophisticated instrumental equipment have shown that even under conditions of moderate to strong winds in the month of August, ground inversions do develop after sunset and persist till after sunrise in the layer close to the ground (U.S.A.F. 1967). As in the month of April, inverted lapse rate conditions are found to be present for 12 hours.

October — The temperature reversal between the two levels occurs between 1800 and 1900 hours in the evening and the opposite transition takes place close to 0900 hr. Thus ground inversion is present for 15 hours in this month.

4. The observational data examined in this paper show that nocturnal ground inversion is a persistent feature at Poona in all the months. Its intensity is maximum in the winter months and least in the monsoon months. Large variations occur from day to day and also in different years. Of the four years that were examined, two years showed winter inversions of greater intensity than the other two. Examination of the vapour pressure data for these years confirmed that the atmosphere was drier in the years which showed more pronounced ground inversion. By and large, radiational cooling of the ground and the adjacent air layers is the mechanism that gives rise to the ground inversions of the type covered in this study. It is interesting to note that the inversion continues to persist for some hours after sunrise. The study shows that thermal structure of the air layers close to the ground would favour stagnation of pollutants discharged in these layers for about two-thirds of the day in the winter months in and around Poona. The comparatively calm wind conditions during the night and morning hours would also favour such stagnation.

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