Mausam, (1983), **34**, 3, 327-330

551.511.6 : 551.510.42(540)

Atmospheric turbidity measurements with Volz sunphotometer at a few background air pollution monitoring network stations in India

KRISHNA NAND and S. J. MASKE

Meteorological Office, Pune

(*Received 23 October 1981*)

सार — वायुमंडलीय आविलता के मापन के लिए 1976 में भारत में 10 स्टेशनों का एक संजाल संस्थापित किया गया था। इलाहाबाद, जोधपुर, पुणें और श्रीनगर पर अंकित किए गए आंकड़ों का विश्लेषण कर परिणाम दिये गए हैं। यह देखा गया है कि श्रीनगर को छोड़कर सभी स्टेशनों पर आविलता ग्रीष्म ऋतु में अधिकतम और शरद ऋतु में न्यूनतम होती है। वायुमंडलीय कणों के द्रव्य को अलग करने में (20 से 30 प्रतिशत तक) वर्षा वाहिका और पृक्षालवाहिका काफी कारगर सिद्ध हुई है।

पुणें में मापे गए तरंगदैर्घ्य घातांक का माध्य 0.5 है। मानसून के उत्तरार्ध एवं शरद ऋतु में उसका वार्षिक विचलन अधिक होता है, लेकिन ग्रीष्म ऋतु में वह कम प्रतीत होता है।

ABSTRACT. A network of ten stations was established in India in 1976 for measurement of atmospheric turbidity. The data obtained at Allahabad, Jodhpur, Pune and Srinagar have been analysed and the results are presented. Turbidity is found to be maximum in summer and a minimum in winter at all stations except at Srinagar. Rainout and washout have been found to be quite effective in removing (20 to 30 per cent) the atmospheric particulate matter.

The wavelength exponent measured at Pune has a mean value of 0.5 and exhibits an annual variation with high values during the post monsoon and winter and low values during the summer months.

1. Introduction

Ten stations in India as a part of global Background Air Pollution Monitoring Network (BAPMoN) were established to document the trend in the Schuepp's decadic turbidity coefficient B using the Volz Sunphotometer. The results of turbidity data thus obtained from Allahabad (25° 27′, 81° 44′), Jodhpur (26° 18′, 73° 01′), Pune (18° 32′, 73° 51′) and Srinagar (34° 05′, 74° 50′) from the above network are reported in this paper.

2. Details of measurement

The turbidity coefficient was calculated from single filter sunphotometer measurements made at 0.50 μm at Allahabad, Jodhpur and Srinagar and from double filter measurements (0.44 and 0.64 μm) at Pune, 1974. At Pune, Ångström's wavelength exponent α (Ångström 1964) values were also computed. B values give a measure of aerosol concentration whereas α indicate the size distribution within the limited size spectrum of the aerosols having radii between 0.1 and 1 μm.

3. Errors of measurements

For a more reliable interpretation of data, obtained using Volz sunphotometers, it is essential to know the magnitude of errors in the measurement of the turbidity coefficient and α, arising from observational and instrumental inaccuracies. Shirvaikar *et al.* (1981) have made an error analysis on lines similar to those of Laulainen and Taylor (1974) and their results which are reproduced below are relevant in B and α measurements with sunphotometers.

3.1. *Error in observation of meter deflection*

For an error of ± 0.5 μA in reading the meter, the probable errors in turbidity range from 5 to

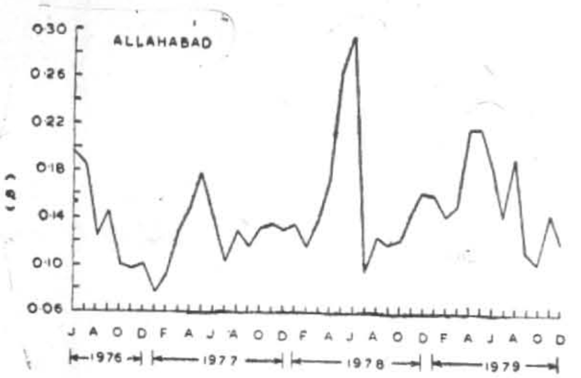

Fig. 1. Monthly variation of decadic turbidity coefficient B at Allahabad [*Read* B instead β]

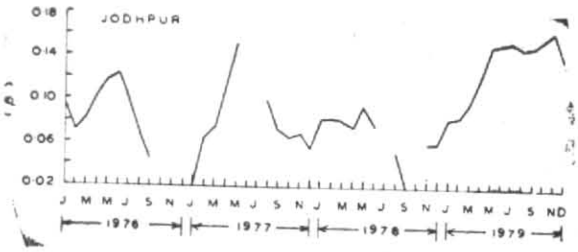

Fig. 2. Monthly variation of decadic turbidity coefficient B at Jodhpur [*Read* B instead β]

TABLE 1

Seasonal values of decadic turbidity coefficient 'B' at background air pollution monitoring stations in India (1977-1979 data)

Station	Winter (Jan-Feb)	Summer (Mar-May)	Post-Monsoon (Oct-Dec)
Allahabad	0.121	0.181	0.126
Jodhpur	0.074	0.108	0.088
Pune	0.099	0.128	0.124
Srinagar	0.111	0.064	0.108

10% as turbidity decreases from 0.5 to 0.1 while errors in α are about 40 to 60% as α decreases from 2.0 to 1.0.

3.2. *Error in extraterrestrial constant* ($Jo\lambda$)

The present method of calibration of sunphotometer is the Langley method. The readings over a range of air-mass (m) values are made during the periods of stable turbidity. The readings are plotted against air mass (m) and then extrapolated to air mass zero to obtain $Jo\lambda$. Typical errors in such estimates may be about 2.5%. This can contribute to an error of 5–25% in turbidity for values between 0.5 and 0.1 and 50 to 80% in α for α values between 2.0 and 1.0.

In fact the errors are very high for turbidity values less than 0.02 and $\alpha<0.5$, sometimes even exceeding 100%. Thus, the use of Volz sunphotometer for turbidity studies may not be appropriate for clean sites.

4. Analysis of data

For the purpose of the present study, daily observational data available between 0830 and 1730 IST during the period 1976-79 have been utilized. The seasonal values of B for different stations were obtained and are presented in Table 1. Sufficient data were not available for the monsoon season. Results from individual stations are discussed in following paragraphs :

4.1.1. *Allahabad*

It is an inland station with a high percentage frequency of occurrence of ground inversion during post monsoon and winter seasons. During the summer season the station experiences duststorms and relative humidity is quite low (about 28%) whereas during post monsoon and winter season it increases to about 60%. Monthly mean values of daily turbidity coefficient as obtained for the station for the years 1976-79 are given in Fig. 1. The highest turbidity coefficient B occurs during summer months as expected. During the post monsoon months when the atmosphere has been cleansed by rain, the lowest values of B are observed. The observed values of B at Allahabad during the post monsoon and winter seasons are almost identical. In general, higher B values are observed during the afternoon in summer which may be ascribed to the high convection and turbulence.

4.1.2. *Jodhpur*

Situated in the Rajasthan desert it has a high percentage frequency of occurrence of ground inversions during the post monsoon and winter seasons. During summer the station experiences very high duststorm activity and particulate matter upto a considerable depth in atmosphere has been observed over this station (Bryson *et al.* 1963). Throughout the year relative humidity at the station remains quite low (26 to 36%) and temperatures during the summer are high. These factors are quite favourable for the injection of large number of particulate in the atmosphere and an increase in turbidity. The monthly mean of daily B values for the station are plotted in Fig. 2. Shirvaikar *et al.* (1981) had observed similar variations at Kota (Rajasthan).

4.1.3. *Pune*

It is an elevated station situated on the leeward side of the Western Ghats, with infrequent ground inversions. The relative humidity during

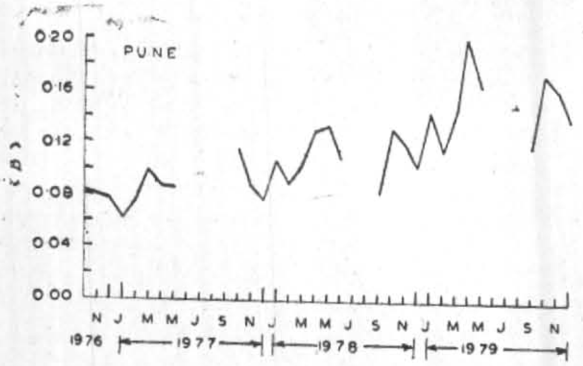

Fig. 3. Monthly variation of decadic turbidity coefficient B at Pune [*Read* B instead β]

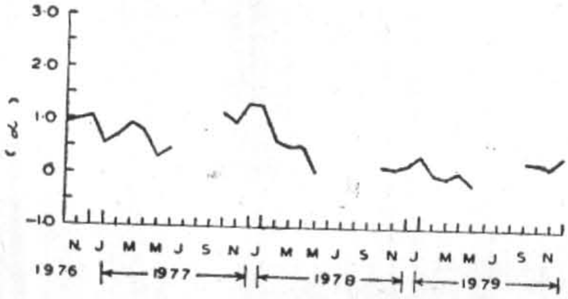

Fig. 4. Monthly variation of α values

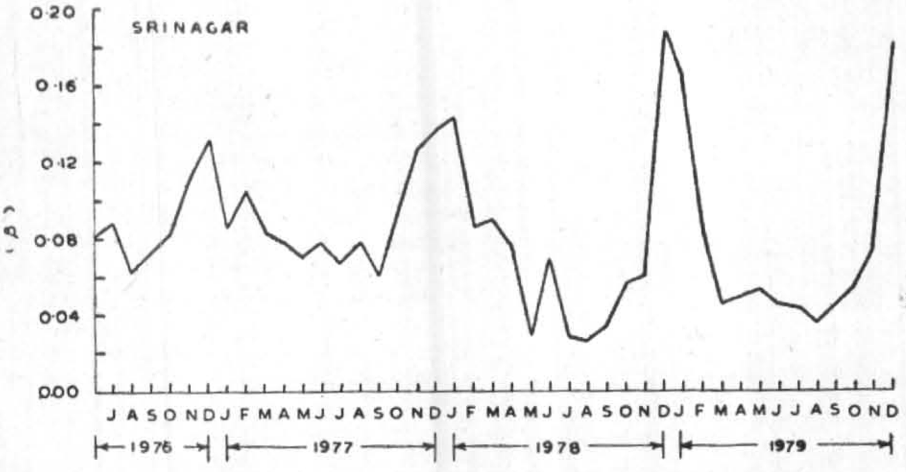

Fig. 5. Monthly variation of decadic turbidity coefficient B at Srinagar [*Read* B instead β]

summer is about 41%. Urbanization and industrialization contribute significantly to the higher turbidity. The monthly mean of daily B for the station are plotted in Fig. 3.

The monthly means of the daily wavelength exponent α values at Pune are plotted in Fig. 4. It is seen that α has a very high annual variation. The minimum value of α was observed to be — 0.14 during May and maximum 1.3 during Dec/Jan. As expected, the value of α is low during the summer season (0.26) and comparatively higher during the winter (0.63) and the post monsoon season (0.65). The annual mean value of α is about 0.5 (1977-1979). Quite interestingly there has been a decreasing trend, which is statistically significant in the α values from 1977 to 1979. Values of α during 1977, 1978 and 1979 were 0.83, 0.47 and 0.17 respectively. Low values of α suggest the preponderance of large size particles in the atmosphere over Pune in comparison to middle latitude stations.

4.1.4. *Srinagar*

It is a hill station with high relative humidity throughout the year (66 to 81%). Turbidity data from this station are plotted in Fig. 5. At this station low values of B have been observed during the summer months and higher values during winter months which is opposite to the trend as observed at other stations. Generally maximum turbidity is observed during the months of December/January.

4.2. *Turbidity trends*

With a view to study trends in turbidity, the annual arithmetic mean of turbidity values for Allahabad, Jodhpur, Pune and Srinagar were calculated and these are plotted in Fig. 6.

There is an increasing trend in B at Allahabad and the increase during 1978 (.158) and 1979 (.159) though statistically significant with respect to 1977 (0.127) value is well within the error limit of measurements.

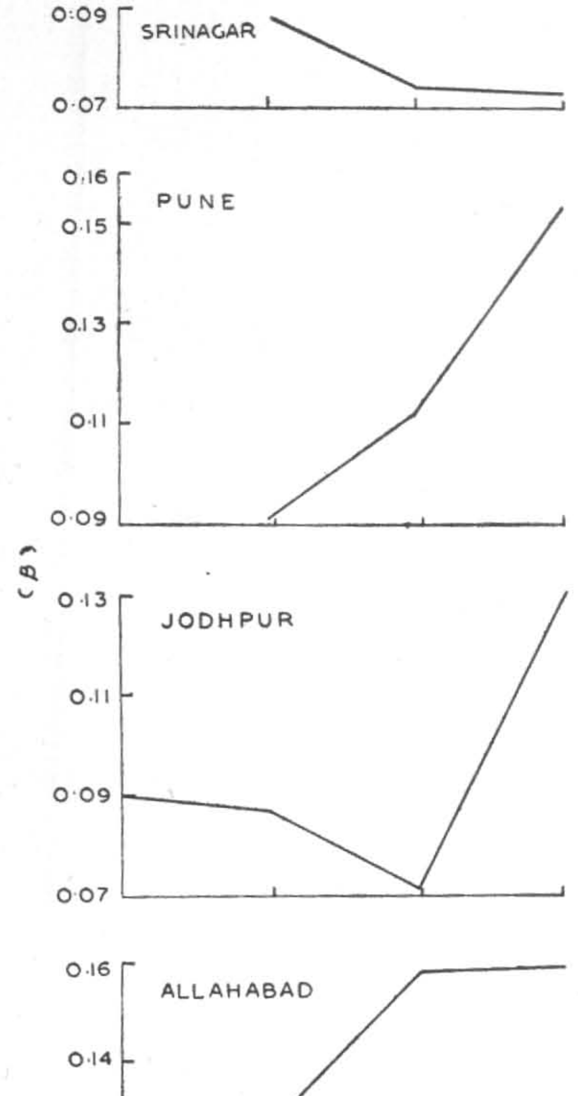

Fig. 6. Yearly variation of B
[*Read* B instead β]

There had been a decreasing trend in B at Jodhpur from 1976 (0.090) to 1978 (.071) which is not statistically significant. However, turbidity value in 1979 (.131) showed a sudden increase. The increase in the annual arithmetic mean value of B between 1978 (.071) and 1979 (0.131) is statistically significant.

The increasing trend at Pune is more obvious and the yearly increments in B values from 1977 (0.091) to 1979 (0.153) are statistically significant. However, when the above turbidity values are compared with mean turbidity values at 0.123 for the years 1966-1967 and 0.105 for 1968 as reported by Mani *et al.* (1969), the increase in B between 1977 and 1979 does not appear to be significant.

A further close study of B values as reported by Rangarajan (1972) for the month of November 1970 (0.070), by Mani *et al.* (1969) for November 1968 (0.075) and the mean value for the month of November during the years 1966 and 1967 (0.120) indicate that the large variation in B during different years can occur even, otherwise which may not be directly related to industrialization and urbanization.

Turbidity data from Srinagar indicate a decreasing trend (1977 to 1979) which is not statistically significant.

5. Conclusions

Turbidity coefficient (B) shows large annual variations with a maximum during summer and a minimum during winter at all stations except at Srinagar.

The maximum value of turbidity has been observed at Allahabad (0.181) during summer.

Rainout and washout are found to be quite effective in removing (20 to 30%) atmospheric particulate matter. However, the efficiency at Pune (23%) was found to be low compared to those at Allahabad (33%) and Jodhpur (32%), possibly due to the fact that atmosphere at Jodhpur and Allahabad contains larger size particulate matter during summer. The mean value of α at Pune is about 0.5 with righ values during the post monsoon and winter and low values during summer.

Acknowledgements

Authors are thankful to Dr. R. P. Sarker, Deputy Director General of Meteorology, Pune for his encouragement and for useful discussions during the preparation of the paper.

References

Ångström, A., 1964, The parameters of atmospheric turbidity, *Tellus,* **16,** 64-75.

Cerf, A., 1980, Atmospheric turbidity over west Africa, *Contributions to Atmospheric Physics,* **53**, 3.

Flowers, E.C., McCormik, R.A. and Kurfis, K. R., 1969, Atmospheric turbidity over the United States, 1961-1966, *J. Appl. Met.*, **8**, 955-962.

Laulamen, N.S. and Taylor, B.S., 1974, The precision and accuracy of Volz sunphotometry, *J. Appl. Met.*, **13,** 2, 298-302.

Mani, A., Chacko, O. and Hariharan, S., 1969, A Study of Ångström's turbidity parameters from solar radiation measurements in India, *Tellus,* **21,** 6, 829-843.

Rangarajan, S., 1972, Wavelength exponent for haze scattering in the tropics as determined by photoelectric photometers, *Tellus,* **24,** 56-64.

Shirvaikar, V.V., Sitaraman, V., Daoo, V.J., Abrol, V. and Sastry, P.L.K., 1981, Turbidity measurements at coastal and inland sites in India, *PAGEOPH,* **119,** 24-30.

W.M.O. (World Meteorological Organization), 1974, WMO operations manual for sampling and analysing techniques for chemical constituents in air and precipitation, WMO Tech. Note 299.