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STUDY OF AEROSOLS OVER DIFFERENT LOCATIONS OF INDIA

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ABSTRACT
Atmospheric aerosols are the suspension of colloidal particles in air. Aerosol measurements have been carried out at different locations in India, by using Semiautomatic Twilight Photometer, which is indigenously designed and developed at IITM, a tropical station, Pune. The basic principle of this technique is if more number of aerosols exists in the atmosphere then more the scattering takes place. Twilight technique is capable of giving the qualitative picture of aerosol vertical distribution from about 6 km to a maximum of 350 km. Aerosol loading at lower troposphere is slightly lower for coastal area than Kolhapur (16°42′N, 74°14′E) and at higher atmospheric layers remain almost the same over different locations for volcanically quiescent period.

KEY WORDS: Colloidal particle (aerosols), Twilight technique, aerosol vertical distribution, Twilight Photometer, troposphere

INTRODUCTION

Atmospheric aerosols are the suspension of colloidal particles in air. Aerosols affect our environment at the local, regional, and global levels. During the course of the study, the measurement of the atmospheric aerosols carried out by using semiautomatic twilight photometer during the period of 1 January 2009 to 31 December 2011 at location Kolhapur (16°42′N, 74°14′E), Maharashtra state, India. One attempt was also made to carry out aerosol measurements at different places having different elevations over coastal area, by using Semiautomatic Twilight Photometer. Twilight observations have been carried out during the period 27 November 2009 to 2 December 2009 at coastal area to compare the vertical distribution of aerosols over different locations. The Semiautomatic Twilight Photometer is capable of giving the qualitative picture of vertical distribution of aerosols suspended in the atmosphere between 6 km to 350 km.

The climatic conditions for Kolhapur and coastal area are different. So this attempt was made to study the difference in the vertical distribution of aerosols between these locations. The distance between Kolhapur and these locations is ~160 Km. Kolhapur city, a location in the south-waste Maharashtra is free from any large scale industrial and urban activities or biomass burning and also surrounded by agricultural land mainly. It has an elevation of 569 meters which is much higher than that of coastal area. Kolhapur's climate is a blend of coastal and inland climate of Maharashtra. Climate in the coastal area is mainly moist and humid. Data has been collected from different locations in coastal area as shown in Table-1.

MATERIALS AND METHODS

The instrument, **semiautomatic** twilight photometer, consists of a telescopic lens of diameter 15 cm having a focal length of 35 cm., a red glass filter peaking at 670 nm with a half band width of about 50 nm, a detector (A photomultiplier tube (PMT)-9658B), and a power supply. The output signal (current) of the PMT, used for detecting the light intensity during the twilight period, is of the order of nano to microamperes. The amplitude or strength of this low signal is amplified by using newly designed fast pre-amplifier during this study. The more details regarding Fast pre-amplifier were given elsewhere, (Mane *et al.*, 2012, “a”). The amplifier output recorded by the digital multimeter, Rishcom-100, having an adapter can store the data automatically for every 10secs in the form of date, time (t) and intensity (I) in Volts. The detail construction and working of this instrument is given by Mane et al. (2012, “b”)

The method used is the twilight sounding method. As the sun is within 0-18º below the horizon, twilight sets. The boundary layer between the illuminated and shadowed is called as twilight layer. In this method, the solar radiation scans the Earth’s atmosphere during the enhancement of the twilight. It is assumed that bulk of the scattered light comes to an observer from the lowest, and therefore densest, layer in the sunlit atmosphere at the time of measurement. The contribution of the rest of the atmosphere above this layer can be neglected due to an exponential decrease of air density with increasing altitude. The height of this lowest layer (twilight layer) increases with increasing earth's shadow height. The lower atmospheric layers now submerged in shadow, no longer contribute to the sky brightness, and the scattered light comes more and more from the higher altitudes, which are still illuminated by direct sunlight. The method for calculating the earth's geometrical shadow height (h) is given by Shah (1970).

RESULTS AND DISCUSSION

The measured scattered light intensity (I) in terms of Volts and the corresponding time (t) constitute the raw data. Figure-1-a shows the plot of the raw data. The observation time was converted to solar zenith angle ‘Z’, which in turn used in the computation of the shadow height of the earth. A time sequence of such records was converted to a record of variations in the light scattering ability of the atmosphere as a function of the altitude. The logarithmic gradient of the intensity parameter provides the information about the aerosol particles. Thus the earth's shadow height (h) and the logarithmic gradient of intensity [(1/I) (dI/dh)] are the two important parameters of twilight method.

Table 1: Different observational locations in coastal area

Location of Ganpatipule in Maharashtra and India	
Coordinates	17°08′41″N 73°16′00″E17.1448°N 73.2666°E
Country	India
State	Maharashtra
District(s)	Ratnagiri
Time zone	IST (UTC+5:30)
Area • Elevation	• 0 m (0 ft)

Location of Sawantwadi in Maharashtra and India	
Coordinates	/ 16°N 73.75°E
Country	India
State	Maharashtra
District(s)	Sindhudurg
Population	22,871 (2001)
Time zone	IST (UTC+5:30)
Area • Elevation	• 111.86 m (367 ft)

Location of Terekhol in Goa and India	
Coordinates	15°29′N 73°50′E15.738278°N 73.72228°E
Country	India
State	Goa
District(s)	North Goa
Time zone	IST (UTC+5:30)
Area • **Elevation**	• 7 m (23 ft)

Location of Harmal Beach in Goa and India	
Coordinates	15°29′N 73°50′E15.40°N 73.42°E
Country	India
State	Goa
District(s)	North Goa
Time zone	IST (UTC+5:30)
Area • **Elevation**	• 5 m (16 ft)

Table 2: Aerosol loading, 'Q' over Kolhapur and different locations at coastal area

Height intervals (Km)	Aerosol loading, 'Q'				
	Sawantwadi	Harmal beach	Terekhol	Ganpatipule	Kolhapur
6-10	149.3866	209.7248	216.3685	242.2602	312.7163
11-16	21.24922	29.33004	22.66526	-	43.6172
17-30	40.50658	45.14917	51.8899	-	55.59332
30-50	21.29801	18.28403	-	-	19.93702
51-65	7.45194	6.45908	-	-	7.41891
66-80	5.40997	4.88062	-	-	6.58588

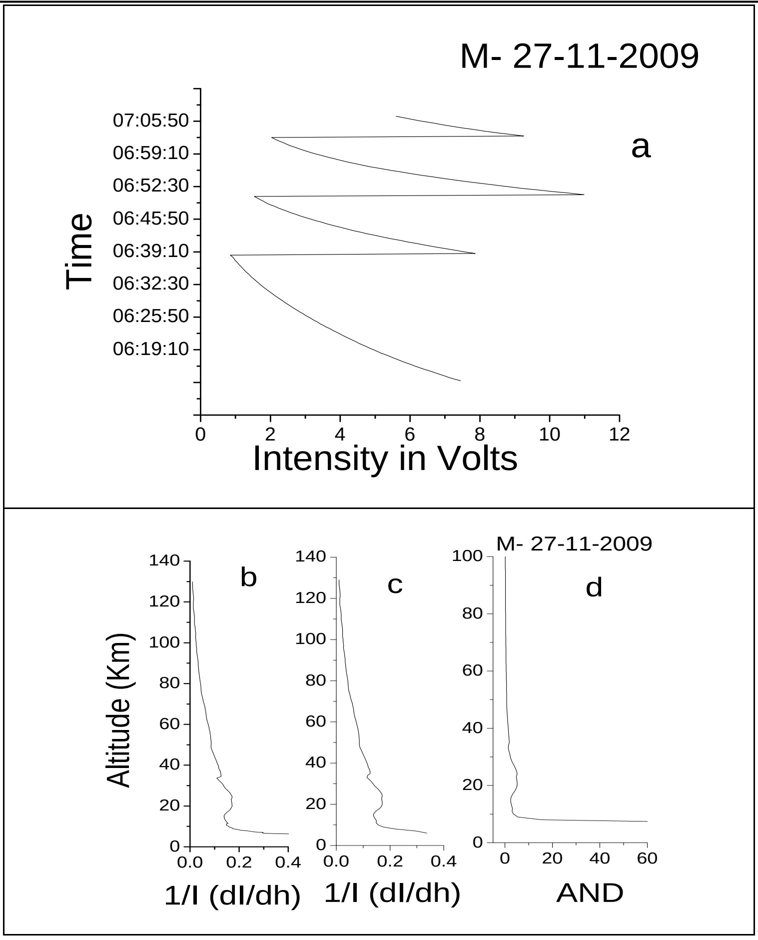

Figure 1. Typical profile of (1/I) (dI/dh) against shadow, heights (h) obtained during very clear sky day

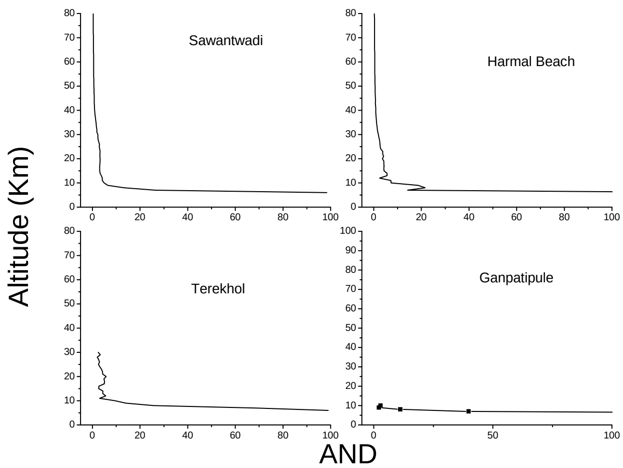

Figure 2. The vertical profiles of AND against shadow height (h) for different locations at coastal area

Figure-1-b shows typical profile of (1/I) (dI/dh) against shadow heights (h) obtained during very clear sky day. It is clear from this Fig that the value of (1/I) (dI/dh) decreases with height, implying a decrease of aerosol number density with height. In lower stratosphere, the value of (1/I) (dI/dh) increases slightly due to the presence of stratospheric dust layer, which is also called as Junge layer (Junge *et al.*, 1961). After that, the value of (1/I) (dI/dh) decreases as the altitude increases. Similar type of vertical distribution of atmospheric aerosol had been reported by many of the earlier workers Shah (1970), Jadhav and Londhe (1992), Nigut *et.al.* (1999) and Padma Kumari *et al.* (2002, 2004, 2006, 2008) using twilight photometric measurements. To validate the photometer-derived profiles, simultaneous observations of photometer and Lidar were carried out at National MST Radar facility (NMRF), Gadanki. The comparison is found to be very good and it is proved that twilight technique provides qualitative information on the vertical distribution of aerosols (Padma Kumari *et al.*, 2004).

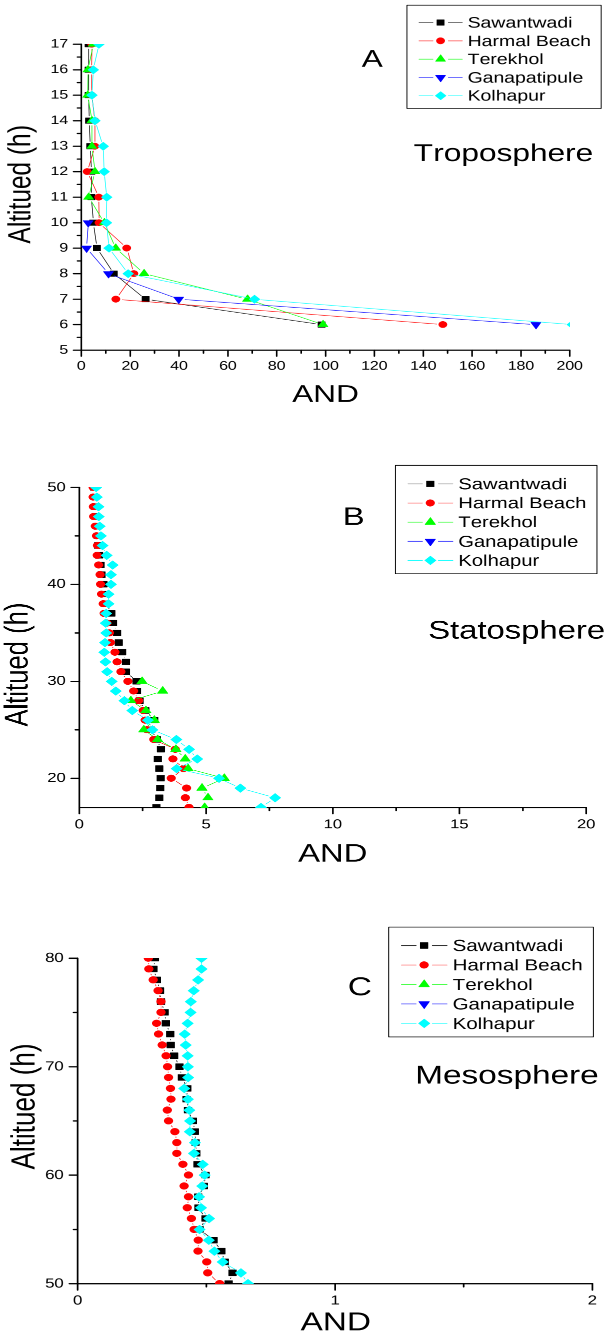

Figure 3: Comparison between typical profiles of AND plotted against 'h' in volcanically quiescent period for troposphere, stratosphere and mesosphere at different locations

These typical photometry curves need some corrections. The sampling interval for 'shadow height (h)' is not constant. By using interpolation technique (Origin 7) the vertical profiles are converted into 1 km 'shadow height (h)' resolution profiles. Figure-1-c shows the same typical profile with interpolation.

Aerosol number density per cm^3 (AND/ cm^3) was calculated for each point of 'shadow height (h)'by using empirical formula stated as,

Aerosol number density per cm^3 = $Antilog_{10}$ {10['1/I (dI/dh)']-1}

Figure-1-d shows the same typical profile with AND plotted against interpolated shadow height (h). The AND profiles derived by imperial formula matches well with general trend of vertical profiles of aerosols.

The vertical profiles of aerosol number density per cubic centimeter (AND) against shadow height (h) for different locations at coastal area are as shown in the Figure-2. Similar types of profiles are obtained at Kolhapur as shown in the Figure-1. While observations were taken at Ganpatipule and Terekhol; cirrus clouds came after some time of starting the observations. Therefore observations were stopped. So, the vertical profiles of AND at Ganpatipule and Terekhol were obtained up to 10 Km and 30 Km respectively. Comparison between the aerosol number density per cubic centimeter (AND) over Kolhapur and different locations of coastal area were studied for different atmospheric levels and results were obtained. The results acquired reveal that in the troposphere, from 6 Km to 10 Km there was considerable difference for AND values at different locations. From 11 Km to 13 Km, there was very small variation, whereas no discrepancy was observed from 14 Km to 17 Km. Again in lower stratosphere at Junge layer some deviations were observed. In stratosphere and mesosphere aerosol number density was the same for all the locations including Kolhapur. Figure-3 shows comparison between typical profiles with AND (the aerosol number density per cm^3) plotted against 'h' (interpolated shadow height), over Kolhapur and different locations in volcanically quiescent period for troposphere (Figure-3-A), stratosphere (Figure-3-B) and mesosphere (Figure-3-C).

Another way to study the comparison is, to calculate the aerosol loading for different intervals of altitude. Using equ.-6, the values of the aerosol loading, 'Q' have been computed for the heights between 6 to 10 Km, 11 to 16 Km, 17 to 30 Km, 31 to 50 Km and 50 to 80 Km, for different locations. Table-2 shows comparison between values of 'Q' at Kolhapur and different locations. It is clear from Table-2 that there is no considerable difference in aerosol loading for upper stratosphere and above atmospheric layers (from 31 Km to 80 Km) between different locations. Thus the aerosol number density remains nearly the same over different locations for stratosphere and above atmospheric layers. Observations on 27 November 2009 –Morning and 26 November 2009 –Morning at Kolhapur are considered for these comparisons.

The aerosol loading for middle troposphere (from 6 to 10 Km) is very large for Kolhapur, comparatively smaller for locations at sea showers viz., Ganpatipule, Terekhol and Harmal beach, and low for Sawantwadi. In Kolhapur both natural and anthropogenic aerosols are present, whereas at sea showers only natural aerosols enriched with sea salt are present. But in Sawantwadi, both natural and anthropogenic aerosols are present with small quantity. The aerial distance between sea showers and Sawantwadi is ~30 Km. In upper troposphere (from 11 to 16 Km), difference between 'Q' at sea showers and Sawantwadi was very small, however Kolhapur showed larger values of 'Q'. In case of lower stratosphere (from 17 to 30 Km), 'Q' values were different because aerosol number density at Junge layer was different for various locations. From all of these observations it was concluded that aerosol number density is different at tropospheric level and Junge layer level for different locations within aerial distance ~200 Km; however no any considerable difference at stratospheric and above levels.

SUMMARY AND CONCLUSIONS

The measurements using the twilight sounding method suggest the following,

- The AND profiles derived by empirical formula matches well with general trend of vertical profiles of aerosols.
- Aerosol number density is different at tropospheric level and Junge layer level for different locations within aerial distance ~200 Km; however no any considerable difference at stratospheric and above levels.

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