URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Temporal Variation of Atmospheric Aerosols and Associated Optical and Metrological Parameters

P. Kumar*[(1)], A. Choudhary[(2)], A.K. Singh[(1)], R. Prasad [(3)] and A. Shukla[(2)]
[(1)]Department of Physics, Institute of Science, Banaras Hindu University, Varanasi, India
[(2)]Tansport Planning and Environment Division, CSIR-Central Road Research Institute, New Delhi, India
[(3)]Department of Physics, Indian Institute of Technology (BHU), Varanasi, India

Abstract

In the present study the particulate matter (PM) mass concentrations such as $PM_{2.5}$ and PM_{10} for the winter (November 2016-February 2017) and summer (March 2017-May 2017) months were observed and analyzed. The aerosol optical properties such as MODIS-Aqua AOD (Aerosol optical depth) and Angstrom Exponent (AE) were found the significance seasonal variations. Monthly average AOD (~1.00) and AE>1were observed in the winter season. Whereas, in the summer season monthly average AOD (~0.50) and AE<1were observed. High monthly mean aerosol mass loading was recorded for both $PM_{2.5}$ (156.38 ± 21.24 μg/m^3) and PM_{10} (256.54 ± 69.82 μg/m^3) in winter season. Whereas concentrations of $PM_{2.5}$ (25.47 ± 16.95 μg/m^3) in April 2017 and PM_{10} (127.68 ± 51.31 μg/m^3) in May 2017 were found low in summer season, typically exceeding national standard. The mean $PM_{2.5}/PM_{10}$ ratio was ~61% in the winter season, is the indicative of a higher loading of the fine aerosol particles compared to the coarser aerosols in Varanasi. However the unfavorable meteorological conditions are also responsible for the highly increasing atmospheric pollution in Varanasi.

1. Introduction

The aerosols are tiny particulate matter (PM) suspended in the atmosphere. The rapidly increasing atmospheric aerosols are the threat for the near-surface air quality, public health, climate change, visibility and agricultural output. Several studies have been focused to know the climatic effects of atmospheric aerosols [1-3]. AOD is an optical parameter which describes air quality and air conditions. Several researchers have been used AOD for the estimation of PM [4, 5]. Varanasi is one of the most polluted cities situated at the middle Indo-Gangetic Plain in the Northern India [6]. The area is surrounded by various anthropogenic sources such as vehicular emissions, agricultural residues and burning of fossil fuels etc. [7]. Increasing population, industrialization, urbanization and unfavorable meteorological conditions are responsible for the highly increasing atmospheric pollution in Varanasi [8]. These days satellite retrieved information is widely used for the assessment, forecasting and management of air quality [9]. However limited work has been done in Varanasi based on PM, optical properties and meteorological parameters. Results observed in the present study were found to be quite considerable with aerosol optical characteristics measured by several scientific groups throughout the world and will be useful for the environmental and climate modeler.

2. Methodology

The PMs were measured by high volume samplers installed over the roof of the Department of Physics. The $PM_{2.5}$ particles were collected with the help of Fine Particulate Sampler (Envirotech APM550) and PM_{10} samples were collected using Respirable Dust Sampler (Envirotech APM 460NL) during November 2016 to May 2017 in Varanasi, India. The location of the study area lays in the latitude 25.2677° N and longitude 82.9913° E for the collection of $PM_{2.5}$ and PM_{10} particles on twice a week. The mass concentrations of $PM_{2.5}$ and PM_{10} as well as MODIS Aqua AOD and AE during November 2016 to May 2017 were collected and analyzed. The MODIS Aqua AOD at 550nm and AE at 0.412-0.47μm values were collected from the Giovanni website (http://giovanni.gsfc.nasa.gov/giovanni/). The meteorological parameters such as temperature, relative humidity and wind speed were collected from the Indian Meteorological Department (IMD) centre in Banaras Hindu University, Varanasi.

3. Results and Discussions

The collected $PM_{2.5}$ and PM_{10} were analyzed and found that $PM_{2.5}$ was near to twice and PM_{10} was nearly three times more than the National Ambient Air Quality (NAAQ) standard. The $PM_{10-2.5}$ was also observed high in both the seasons. $PM_{10-2.5}$ was calculated by subtracting $PM_{2.5}$ from PM_{10} mass concentrations. During winter season from months November 2016 to February 2017 the mass concentration of $PM_{2.5}$ and PM_{10} were found high. The monthly mean concentrations of $PM_{2.5}$ and PM_{10} were found to be 156.38 ± 21.24 μg/m^3 and 256.54 ± 69.82 μg/m^3 respectively in the month of December 2016 was the highest. However during summer months March 2017 to May 2017 the PM_{10} concentrations were higher than $PM_{2.5}$. Figure 1 show the monthly mean variations in mass

concentrations of $PM_{2.5}$, PM_{10} and $PM_{10-2.5}$ and standard deviation along with NAAQS levels.

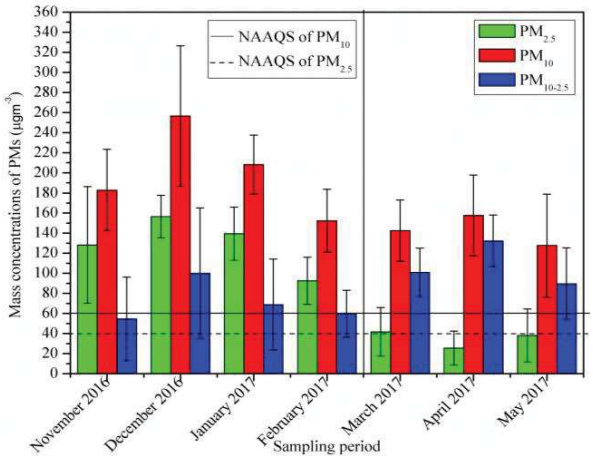

Figure 1. Monthly mean variations in $PM_{2.5}$, PM_{10} and $PM_{10-2.5}$ along with NAAQS levels.

The mean $PM_{2.5}/PM_{10}$ ratio was ~61% in the winter season, is the indicative of a higher loading of the fine aerosol particles compared to the coarser aerosols in winter season. Also the AE>1 values in the winter season are the indicative of the dominant of fine particles in winter season. The higher anthropogenic activities in Varanasi are the major sources for domination of fine particles in winter season. However the AE<1 values in the summer months are the indicative of the course particles domination. Figure 2 show the monthly mean variation in AE and $PM_{2.5}/PM_{10}$.

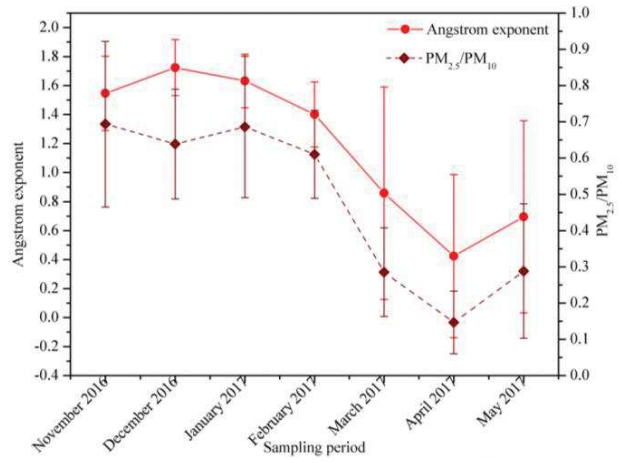

Figure 2. Monthly mean variation in AE and $PM_{2.5}/PM_{10}$.

The MODIS-Aqua AOD and AE were found the significance seasonal variations during both the seasons. Average AOD (~1.00) was observed in the winter season. While average AOD (~0.50) was observed during summer season. Higher values of AOD in winter season indicate about the less dispersion of atmospheric aerosols. The major effect of the aerosols in Varanasi are due to anthropogenic activities, however the biomass burning in Punjab and Haryana also are the concern of atmospheric pollution in Varanasi. Figure 3 show the monthly mean variation in MODIS Aqua AOD and AE.

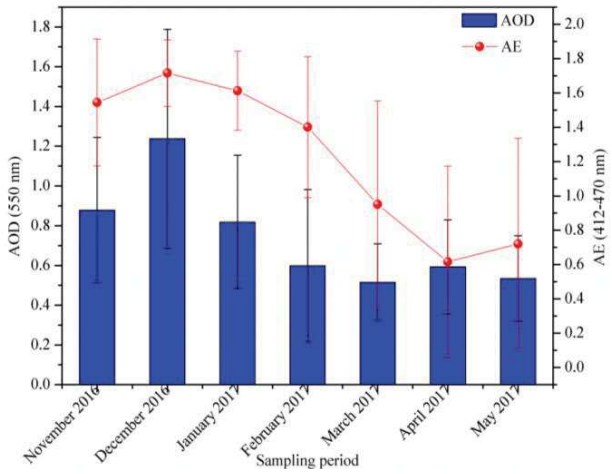

Figure 3. Monthly mean variation in MODIS Aqua AOD and AE.

The temporal variations of meteorological parameters such as temperature, relative humidity and wind speed are shown together in Figure 4. The temperature and relative humidity are inversely correlated to each other. However the wind speed was observed high in the month of May 2017. The high wind speed in the summer months are the carrier of natural sources from the arid regions of the Thar Desert, Afghanistan, Middle East and the Africa (Saharan Desert) have been found to be major contributors of the mineral dust over Varanasi [6, 8].

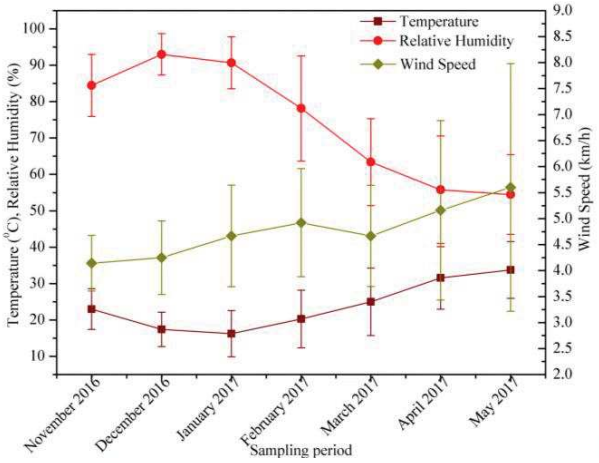

Figure 4. Monthly mean variation in temperature, relative humidity and wind speed.

4. Conclusions

Indo Gangetic Plain is one of the highest aerosol loaded region of India during 2016-17 due to its unique topography and different sources of anthropogenic aerosols. The annual mean of PM_{10} is about nearly three times higher than the standard set by NAAQ (60µg/m3). However, $PM_{2.5}$ is twice higher than the annual standard (40µg/m3) set by NAAQ. The monthly $PM_{2.5}/PM_{10}$ more than 0.6 in winter season indicates the higher loading of fine particles while ratio less than 0.3 indicates the coarse particles are highly loaded in summer season. The AOD loading is found to be high during both summer and winter seasons. In summer season AE<1 values suggesting the coarse-mode aerosol particles are dominant while AE>1 values in winter season suggesting the fine-mode particles are dominant over Varanasi.

6. Acknowledgements

This work is supported by the SERB-DST, New Delhi, India, under the scheme of SERB National Post-Doctoral Fellowship (PDF/2017/001898). The work is partially supported by UGC under MRP program. Metrological data were taken from IMD centre BHU, Varanasi. Authors are also very thankful to https://giovanni.gsfc.nasa.gov/giovanni/ for providing satellite data.

7. References

1. P. V. Hobbs, J. S. Reid, R. A. Kotchenruther, R. J. Ferek, and R. Weiss, "Direct radiative forcing by smoke from biomass burning," *Science*, 275, 1997, pp. 1776–1778.

2. J. E. Penner, D. Hegg, and R. Leaitch, "Unravelling the role of aerosols in climate change," *Environmental Science and Technology*, 35, 2001, pp. 332A–340A.

3. S. Tiwari, A. K. Srivastava, D. S. Bisht, T. Bano S. Singh, S. Behura, M. K. Srivastava, D. M. Chate, and B. Padmanabhamurty, "Black carbon and chemical characteristics of PM10 and PM2.5 at an urban site of North India," *Journal of Atmospheric Chemistry*, 62, 2009, pp. 193–209.

4. S. Dey, L. D. Girolamo, A. Donkelaar, S. N. Tripathi, T. Gupta, and M. Mohan, "Variability of outdoor fine articulate ($PM_{2.5}$) concentration in the Indian Subcontinent: A remote sensing approach," *Remote sensing of environment,* 127, 2012, pp. 153-161.

5. A. K. Srivastava, V. K. Soni, S. Singh, V. P. Kanawade, N. Singh, S. Tiwari, and S. D. Attri, "An early South Asian dust storm during March 2012 and its impacts on Indian Himalayan foothills: A case study," *Science of The Total Environment*, 493, 2014, pp. 526-534.

6. S. Tiwari, D. Kaskaoutis, V. K. Soni, S. D. Attri, and A. K. Singh, "Aerosol columnar characteristics and their heterogeneous nature over Varanasi, in the central Ganges valley," *Environmental Science and Pollution Research*, 25, 2018, 4726-24745.

7. H. Akimoto, "Global air quality and pollution," *Science* 302, 2003, pp. 1716–1719.

8. S. Tiwari, A. K. Srivastava, A. K. Singh, and S. Singh, "Identification of aerosol types over Indo Gangetic Basin: implications to optical properties and associated radiative forcing" *Environmental Science and Pollution Res*earch, 22, 2015, pp. 12246-12260.

9. A. Mhawish, M. Kumar, A. K. Mishra, P. K., Srivastava, and T. Banerjee, "Remote sensing of aerosols from space: retrieval of properties and applications," *Remote Sensing of Aerosols, Clouds, and Precipitation, Publisher: Elsevier Inc,* 2018. pp. 1–38.