Eco. Env. & Cons. 28 (4) : 2022; pp. (1863-1866)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i04.032

Variations of Particulate Matter in Visakhapatnam city of Andhra Pradesh, India

Kavitha Chandu*

Department of Physics, GITAM Institute of Science, GITAM (Deemed to be) University, Vishakhapatnam 530 045, Andhra Pradesh, India

(Received 17 April, 2022; Accepted 30 May, 2022)

ABSTRACT

This paper presents the seasonal variations of particulate matter, short and long-term variations in $PM_{2.5}/PM_{10}$ ratios for 2020-2021 in Visakhapatnam city of Andhra Pradesh, India. The season-wise analysis indicates that 92% and 78% of the time, the 24-hr average value of PM_{10} and $PM_{2.5}$ exceeded the breakpoints in winter. A significant correlation between $PM_{2.5}$ ad PM_{10} was observed in all seasons. The mean ratios of $PM_{2.5}/PM_{10}$ during winter and post-monsoon are higher compared to the other two seasons.

Key words: *Particulate Matter, $PM_{2.5}/PM_{10}$ ratio, Visakhapatnam, Air Quality, Emissions*

Introduction

Particulate matter of aerodynamic diameter ≤ 10 µm (PM_{10}) and ≤ 2.5µm ($PM_{2.5}$) is linked to causing significant health problems. Major concerns for human exposure to PM_{10} include respiratory disorders, damage to lung tissue, and premature death. $PM_{2.5}$ is of specific concern because it contains a high proportion of various toxic metals and can penetrate deeper into the human respiratory tract. In India, several epidemiological studies (Gordon *et al.,* 2018; Maheshwarkar and Sunder Raman, 2021; Manojkumar and Srimuruganandam, 2021; Nazrul Islam *et al*., 2020; Prabhakaran *et al*., 2020) show that higher rates of respiratory and cardiovascular diseases in people are due to exposure to particulate matter.

The air quality in urban areas ((Sarkawt, *et al.,* 2020; Singh *et al.,* 2021), particularly particulate matter, has been receiving more attention as a significant proportion of the population lives in urban areas. In India, rapid industrialization and its concentration in urban areas increased the urban population. Visakhapatnam is the most industrialized city in Andhra Pradesh, India, with major industries such as steel plant, refineries, port, Coromandel fertilizers, pharmaceuticals, etc. Several studies have identified particulate matter as a major pollutant in this place. The main reason is attributed to industrial and domestic activities. In addition to industrial activities, emissions from motor vehicles, road dust, booming construction activities, burning of biomass, use of wood and coal, etc., contribute to ambient air pollution at this site. In winter, the air quality is 'poor to severe' due to the condensation of fine particulate matter in the lower atmosphere. The city is geographically a bowl-shaped area. The atmospheric inversion is also contributing to ambient air quality levels.

Against this backdrop, the study analyses the seasonal variations of particulate matter, short and long-term variations in $PM_{2.5}/PM_{10}$ ratios for 2020-2021 in Visakhapatnam city of Andhra Pradesh, India.

Data and methodology

The real-time hourly mass concentrations of $PM_{2.5}$ and PM_{10} recorded in the National Air Quality Index of Central Pollution Control Board compiled for each city under the Ministry of Environment, Forests and Climate Change, India, are taken for the study, which are publicly accessible. The data used in this paper are obtained from the website (https://app.cpcbccr.com). The 24-hr observations of PM2.5, PM10 in each season (Summer: March, April, and May, Monsoon: June, July, August and September, Post Monsoon: October and November, Winter: December, January, and February) during March 2020 - February 2021 at the present location are considered in the study.

Results and Discussion

The daily average of $PM_{2.5}$ during the winter season is found to be in the range of 31.2-158.4 μg/m³ while PM_{10} ranges between 79.65-299.99 μg/m³. In the post-monsoon period, the average oscillated between 10.36-179.5 μg/m³ in the case of $PM_{2.5}$, and similarly, PM_{10} varied between 17.43-281.13 μg/m³. In summer, $PM_{2.5}$ varied between 2-67.14 μg/m³, and PM_{10} fluctuated between 18.17-203.01 μg/m³. During the monsoon period, $PM_{2.5}$ and PM_{10} varied between 8.15-90.91 μg/m³ and 26.51-213.39 μg/m³, respectively.

The data analysis of PM concentrations is shown in Table 1. It reveals that the 24-hr average value of $PM_{2.5}$ during summer, monsoon, post-monsoon, and winter seasons is found to be 21.46±12.62, 25.98±10.59, 53.98±30.40, and 81.38±26.44 μg/m³, respectively. At the same time, PM_{10} concentrations are found to be ranging between 66.89±30.48, 75.45±26.41, 114.24±60.93, 171.43±59.85 μg/m³ during summer, monsoon, post-monsoon, and winter seasons. The standard deviation was highest in winter and lowest in summer. The highest deviation in winter is attributable to typically low wind speed, favorable inversion conditions, and thereby suspension of particles for long hours.

During post-monsoon, the ratio of $PM_{2.5}/PM_{10}$ ranged between 0.28-0.74, while in summer, monsoon, and winter, the ratios are between 0.11-0.49, 0.18-0.53, 0.28-0.63, respectively. The upper limit of the ratio is high in the post-monsoon (0.74), while the mean of $PM_{2.5}/PM_{10}$ in winter (0.48±0.08) is higher than in other seasons.

The short (daily) and long-term (monthly, seasonal) variations of $PM_{2.5}/PM_{10}$ratios are further analysed to understand the source of origin of particle pollution. The higher ratios indicate anthropogenic sources, while lower ratios indicate the involvement of coarse particles. The daily variation of the ratios and PM concentrations for the entire study period is represented in Figure 1. The values start at 19:00 hr as it's a turning point of daily variations. The figure shows that the ratios decrease from 19:00 to early morning 1:00 AM but peaking at 5:00 AM. The ratios decreased until 8:00 AM and then exhibited an increasing trend, reaching a peak value of 0.45 at 15:00. A modest rise in the ratios is between 12:00 -14:00 hrs.

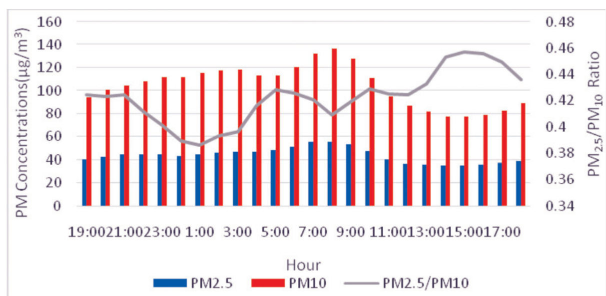

Fig. 1. Daily variation of $PM_{2.5}/PM_{10}$ ratios and PM concentrations

Table 1. 24-hr average values of PM concentrations during four seasons of the year, 2020-2021

Season	$PM_{2.5}$(μg/m³)	PM_{10}(μg/m³)	$PM_{2.5}/PM_{10}$
Summer	21.46±12.62	66.89±30.48	0.31±0.08
Monsoon	25.98±10.59	75.45±26.41	0.34±0.07
Post Monsoon	53.98±30.40	114.24±60.93	0.47±0.10
Winter	81.38±26.44	171.43±59.85	0.48±0.08

The monthly variations of $PM_{2.5}/PM_{10}$ exhibited a decrease from March to May and then increased to January (Figure 2). The lowest ratio (0.24) was recorded in May, while the ratio reached a maximum in January (0.51). There is a gradual change in the ratios from march to January at this location. In terms of seasonality, as shown in Figure 3, the highest ratios are recorded in winter (0.48) and post-monsoon (0.47), while the lowest is recorded in summer (0.34).

Further, for comparative assessment of PM concentrations, the daily average values are classified into six categories. According to Indian air quality standards, the range of values between 0 to 100 are

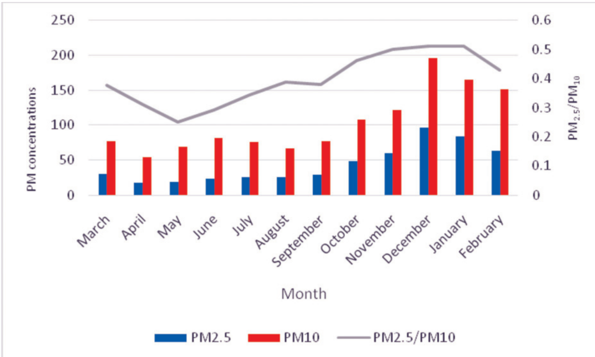

Fig. 2. Monthly variation of $PM_{2.5}/PM_{10}$ ratios and PM concentrations

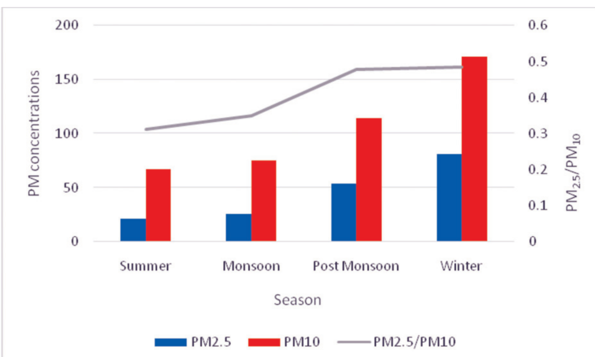

Fig. 3. Seasonal variation of $PM_{2.5}/PM_{10}$ ratios and PM concentrations

categorized as good, 100 to 200 as moderate, 200 to 300 as poor, and above 300 as very poor or severe.

Figures 4 and 5 represent the frequency distribution of $PM_{2.5}$ and PM_{10} for different seasons. The frequency distribution $PM_{2.5}$ concentrations show 68 and 54 % of the time in winter and post-monsoon falling in the range of 50 -100 μg/m^3. In summer and monsoon 76% and 56% of the time, the $PM_{2.5}$ values

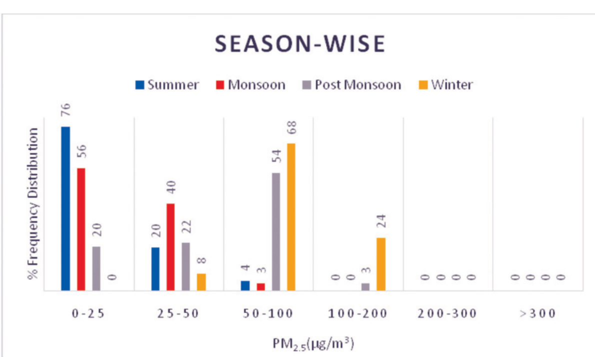

Fig. 4. Frequency distribution of season-wise $PM_{2.5}$ concentrations

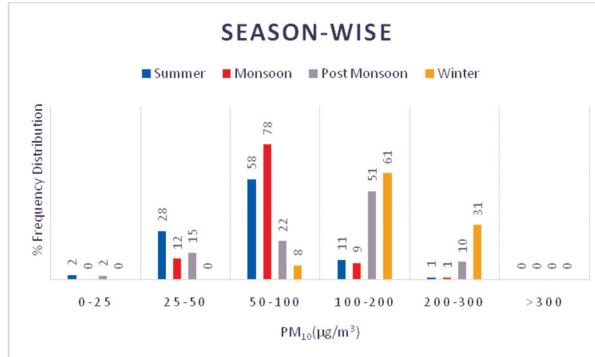

Fig. 5. Frequency distribution of season-wise PM_{10} concentrations

are under 0-25 μg/m^3. The low value in summer is due to dispersion conditions. The frequency distribution of PM_{10} concentrations for post-monsoon indicated that 51% of the time, the values fall under the moderate category, and 10 % of the time, they fall under poor category. Similarly, in the winter season, the PM_{10} concentrations are under the category of moderate to Poor. In summer, about 88% of PM_{10} concentrations fall under the good category, which shows a significant improvement in air quality in the summer season.

According to Indian National Ambient Air Quality Standards (NAAQS), the breakpoints for PM_{10} and $PM_{2.5}$ are 100 and 60 μg/m^3, respectively. The season-wise analysis indicates that 92% and 78% of the time, the 24-hr average value of PM_{10} and $PM_{2.5}$ exceeded the breakpoints in winter. In comparison, 61% and 41 % of the time post-monsoon, the PM_{10} and $PM_{2.5}$ concentrations exceeded the limits as prescribed by NAAQS.

The relationship between $PM_{2.5}$ and PM_{10} showed a high positive correlation. The Pearson correlation coefficient between PMs is high in all seasons (Summer: r =0.89; Monsoon: r = 0.84; post-Monsoon: r = 0.87; Winter: r= 0.85). The significant correlation indicates traffic-related emissions are the main sources of emissions at this site.

Conclusion

1. The monitored data from March 2020- February 2021 reveals that the daily average concentrations are high in winter. The standard deviation of PMs was higher in winter due to inversion conditions.
2. The mean ratios of $PM_{2.5}/PM_{10}$ during winter

and post-monsoon are higher compared to the other two seasons.

3. The study investigated the short- and long-term variations of $PM_{2.5}/PM_{10}$ ratios. The short-term ratio is less than 0.5, indicating higher coarse particle masses. As for monthly and seasonality, the higher ratio is observed in January month (0.51) and winter (0.48) and post-monsoon seasons (0.47).
4. $PM_{2.5}$ concentrations show that 68 and 54 % of the time in winter and post-monsoon are in the range of 50 -100 $\mu g/m^3$. The PM_{10} concentrations are under moderate to a poor category in winter and post-monsoon seasons.
5. The season-wise analysis indicates that 92% and 78% of the time, the 24-hr average value of PM_{10} and $PM_{2.5}$ exceeded the breakpoints in winter.
6. A significant correlation between $PM_{2.5}$ ad PM_{10} is observed in all seasons, indicating traffic-related emissions as the primary sources of emissions at this site.

References

Gordon, T., Balakrishnan, K. and Dey S. 2018. Air pollution health research priorities for India: Perspectives of the Indo-U.S. Communities of Researchers. *Environ Int*. 119 : 100-108. doi: 10.1016/j.envint.2018.06.013

Maheshwarkar, P. and Sunder Raman, R. 2021. Population exposure across central India to $PM_{2.5}$ derived using remotely sensed products in a three-stage statistical model. *Sci Rep*. 11 : 544,https://doi.org/10.1038/s41598-020-79229-7

Manojkumar, N. and Srimuruganandam, B. 2021. Health effects of particulate matter in major Indian cities. *Int J Environ Health Res*. 31(3): 258-270. doi: 10.1080/09603123.2019.1651257. Epub 2019 Aug 8. PMID: 31392891.

Nazrul Islam, Anjum Dihingia, Puja Khare and Binoy K. Saikia, 2020. Atmospheric particulate matters in an Indian urban area: Health implications from potentially hazardous elements, cytotoxicity, and genotoxicity studies. *Journal of Hazardous Materials*. 384:121472, ISSN 0304-3894,https://doi.org/10.1016/j.jhazmat.2019.121472.

Prabhakaran, Poornima, Jaganathan, Suganthi, Walia, Gagandeep K., Wellenius, Gregory A., Mandal, Siddhartha; Kumar, Kishore, Kloog, Itai, Lane, Kevin, Nori-Sarma, Amruta, Rosenqvist, Marten, Dahlquist, Marcus, Reddy, K. Srinath, Schwartz, Joel; Prabhakaran, Dorairaj, Ljungman, Petter L.S. 2020. Building capacity for air pollution epidemiology in India. *Environmental Epidemiology*. 4 (5) :e117,doi: 10.1097/EE9.0000000000000117

Prasannavenkatesh, Ramachandran, Ramachandran, Andimuthu, Palanivelu, Kandasamy, Rajadurai, Geetha, Subash Kumar, Divya, Radhapriya, Parthasaathy and Ponnusamy, Malani, 2015. Assessment of Population Exposure to Coarse and Fine Particulate Matter in the Urban Areas of Chennai, India. *The Scientific World Journal*. 10.1155/2015/643714.

Sarkawt, M.L. Hama, Prashant Kumar, Roy M. Harrison, William J. Bloss, Mukesh Khare, Sumit Mishra, Anil Namdeo, Ranjeet Sokhi, Paul Goodman and Chhemendra Sharma, 2020. Four-year assessment of ambient particulate matter and trace gases in the Delhi-NCR region of India, Sustainable Cities and Society. 54 : 102003, ISSN 2210-6707,https://doi.org/10.1016/j.scs.2019.102003.

Singh, V., Singh, S. and Biswal, A. 2021. Exceedances and trends of particulate matter (PM2.5) in five Indian megacities. *Sci Total Environ*. 750 : 141461. doi:10.1016/j.scitotenv.2020.141461