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Trend in Particulate air pollutants in Visakhapatnam city for 2018-2020: A case study

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ABSTRACT

Rapid industrialization aided by urbanization led to severe air pollution in Visakhapatnam city, with prominent pollutant being particulate matter (PM_{10}). This paper aims to anlyse the trend in particulate matter over a three year period, 2018-20. The results indicate high mass concentrations of PM_{10} in winter, mostly exceeding NAAQS limits. Clearer air quality is observed in summer and monsoon seasons. The city's bowl-shaped area promotes accumulation of pollution in winter.

Key words: *Particulate matter, Visakhapatnam, Air pollution.*

Introduction

Visakhapatnam is one of the non-attainment cities identified by the central pollution control board (CPCB) for not meeting National Ambient Air Quality Standards (NAAQS). The city is a bowl area lying between two major hilly regions -Yarada and Adavivaram. The city has emerged as one of the leading industrial centers in southern India. The major industries responsible for contributing to significant air pollution at this site are coromandel fertilizers, Visakhapatnam port trust, Hindustan Zinc Limited, Hindustan petroleum corporation limited, LG polymers, and Essar steel.

Particulate matter have been identified as major pollutants due to industrial and domestic activities, while the gaseous emissions are within the limits of NAAQS standards. In the winter season, the air quality is poor due to the condensation of fine particulate matter in the lower portion of the atmosphere because of the city's bowl-shaped area.

Several studies identified particulate matter as a significant pollutant at this site (Kavitha Chandu and Madhavaprasad Dasari, 2020). Lakshmana Rao, in 2014 reported that the particulate pollutants are emerging as critical pollutants at this location, and the air quality in the winter season is more polluted and unhealthier. Sandeep *et al.* (2016) reported that average PM_{10} mass concentrations observed at Jogannapalem and Parawada sites in Visakhapatnam exceeded the CPCB annual limit (60 mg/m^3). PM and associated chemical species pollution were observed to be high during winter and lowest during monsoon season. A study by Lankapalli, Kala (2021) on air pollutants from January 2018-December 2020 for nine monitoring stations in Visakhapatnam observed that maximum $PM_{2.5}$ levels fall within the range of 61-90 µg/m^3 and PM_{10} ranged between 101-250 µg/m^3 in 2019 and 2020, indicating air pollution status as 'Moderately polluted according to AQI.

Against this backdrop, the present paper aims to analyse the trend in particulate matter during the period 2018-2021.

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. The publicly accessible data is obtained from the website (https://app.cpcbccr.com). The 24-hr observations of $PM_{2.5}$, PM_{10} in each season, Summer: (March, April, and May), Monsoon: (June, July, August, and September), Post Monsoon: (October and November), and winter: (December, January, and February) during March 2018 - February 2021 at the present location are considered in the study. The three years considered are- March 2018 – February 2019, March 2019 -February 2020, March 2020- February 2021.

Results and Discussion

Table 1 shows the presence of major air pollutant as a percentage of total days per year. The most prominent pollution at the study site is PM_{10}. It is the main pollutant for 60.8 % of days in 2018, followed by $PM_{2.5}$ being a significant pollutant in 21.6% of the days. There is no significant variation in the incidence of the particulate matter in 2019 compared to 2018. However, in a higher percentage of days, both the pollutants are present in 2020.

Table 1. Annual variations in $PM_{2.5}$ (µg/m^3) and PM_{10} (µg/m^3)

	$PM_{2.5}$	PM_{10}
2018	21.6%	60.8%
2019	20.2%	61.2%
2020	22.3%	67.4%

Monthly Variations

Figure 1 shows the average monthly variations in particulate matter (PM_{10} and $PM_{2.5}$) for 2018-2020. The average PM_{10} concentration exceeded the national air quality standard from October to February. The highest average value of 165.95 µg/m^3 was recorded in January, and the second-highest was registered in December (142.61 µg/m^3). The PM_{10} concentration was lower than national air quality standards from March to September, with a minimum value of 73.10 µg/m^3 in April.

A similar trend is observed in $PM_{2.5}$ concentrations, with the highest average value of 85.85 µg/m^3 recorded in January and the least value of 22.80 µg/m^3 registering in April. However, the average mass concentration of $PM_{2.5}$ was lower than the standard value of 60 µg/m^3 in nine months from February to October.

The low values of PMs in the summer months can be attributed to dispersion conditions, and higher values in winter were due to inversion conditions and condensation of fine particulate matter in the lower atmosphere.

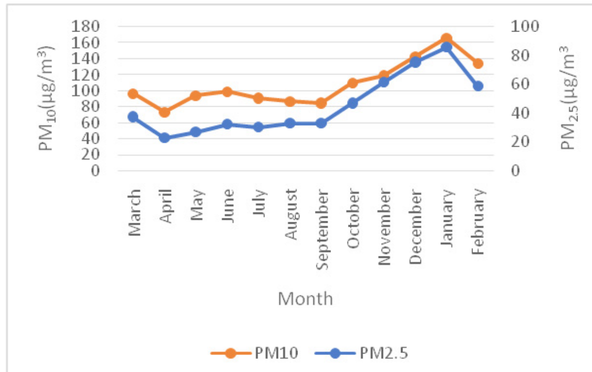

Fig. 1. Average monthly variations in PM Concentrations for the period 2018-2020

Seasonal Variations

Seasonal variations of PMs are displayed in Figures 2 and 3. Seasonal average mass concentrations of PMs show that air quality is clearest in summer. Season-wise variations exhibited a linear trend from summer to winter in 2018 and 2020. While in 2019, the particulate matter mass concentrations show a fluctuating trend. The change in meteorological conditions also affects the annual changes in pollutant levels. There is a decrease in particulate matter concentrations in 2020 compared to 2018 due to stringent lockdown imposed from March 2020 because of the covid pandemic.

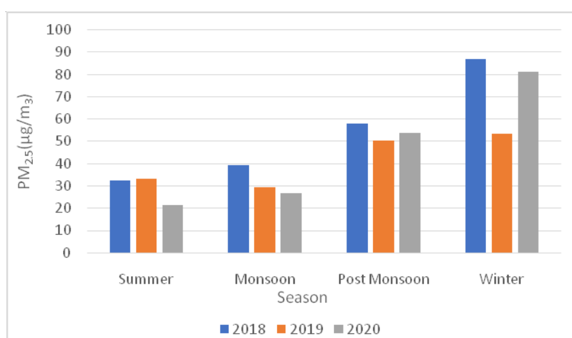

Fig. 2. Seasonal Variations in $PM_{2.5}$ (µg/m^3) (2018-2020)

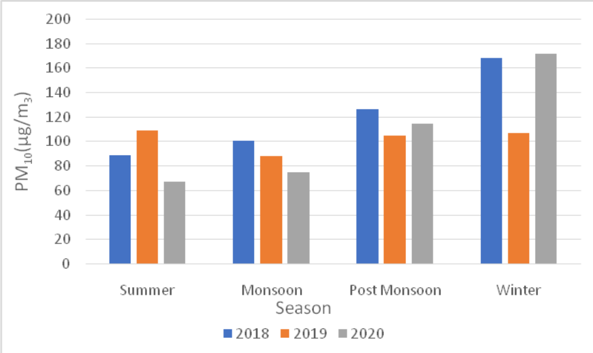

Fig. 3. Seasonal Variations in PM_{10}(µg/m^3) (2018-2020)

$PM_{2.5}/PM_{10}$ average ratios

A low ratio of $PM_{2.5}/PM_{10}$ indicates the dominance of dust, and a high ratio denotes anthropogenic aerosols during the season. The seasonal and monthly variations for the study period show a similar trend,with higher values in the winter (0.49) and in December and January (0.51). Lower values are recorded in the summer season (0.32) and in May month (0.27). The ratio is less than 0.5 for the entire study period indicating existence of higher coarse particle masses.

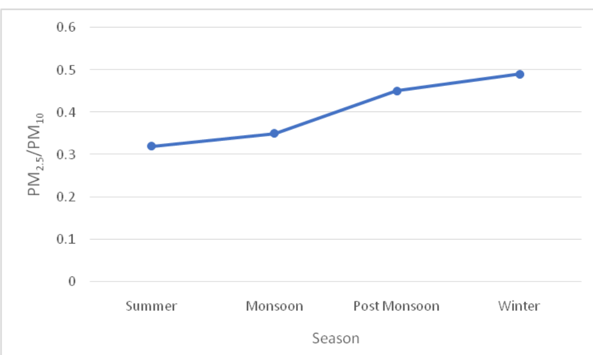

Fig. 4. Seasonal variations of $PM_{2.5}/PM_{10}$

Frequency Distribution

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 for the entire study period indicates that 74% and 61% of the time, the 24-hr average value of PM_{10} and $PM_{2.5}$ respectively exceeded the breakpoints in winter. In comparison, 69% and 43 % of the time in post-monsoon season, the PM_{10} and $PM_{2.5}$ concentrations exceeded the limits as prescribed by NAAQS. In summer and monsoon, 34% and 24 % of the time, the PM_{10} values and 5% and 3% of the time the $PM_{2.5}$ values exceeded the limits.

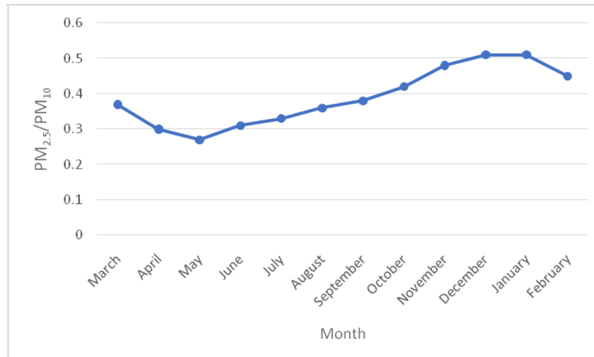

Fig. 5. Monthly variations of $PM_{2.5}/PM_{10}$

Pearson Correlation

The relationship between $PM_{2.5}$ and PM_{10} showed a high positive correlation. The Pearson correlation coefficient between PMs over the period 2018-2020 is high in all seasons (Summer: r =0.88; Monsoon: r = 0.79; post-Monsoon: r = 0.85; Winter: r= 0.86). The significant correlation indicates that traffic-related emissions are the main sources of pollution at this site.

Conclusion

The major conclusion that emerged from the study is that Visakhapatnam recorded high pollution in the winter season irrespective of the measurement by month and season. PM_{10} is the predominant pollutant, which exceeded NAAQs for a significant part of the period.

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