RESEARCH ARTICLE

Study of PM2.5 Distribution, its Relation with Metrological Parameters and Mitigation Over Delhi Region

Ananna Bardhan[1*], Anshuman Sahai[1], Vinayak V. Pathak[2], DK Sharma[1], Meena Kapahi[2], SK Shukla[2]

[1]*Department of Physics, Manav Rachna University, Faridabad, Haryana, India*
[2]*Department of Chemistry, Manav Rachna University, Faridabad, Haryana, India*

***Corresponding author:** Ananna Bardhan, Department of Physics, Manav Rachna University, Faridabad, Haryana, India, Tel: +918860836871, E-mail: ananna@mru.edu.in

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ABSTRACT

Urbanization has facilitated the human life. However, on the flip side has invited a lot of adversity on the human lives. Air pollution is one the major concerns and enhanced levels finer air pollutants - particularly PM2.5 makes the situation rather more critical. Presently, the analysis of distribution of PM2.5 on different temporal scales - monthly, daily and diurnal over a period of two years (2016 and 2017) have been carried for Near Capital Territory (NCT)/Delhi region. The seasonal variations are quite evident. The maximum concentration of PM2.5 is observed in winters than in summers and least during monsoon months. The diurnal variation also shows strong dependence on the seasonal conditions. The winter months (November, December and January) shows higher concentration of PM2.5 during the daytime compared to the night time. The summer and monsoon months (May, June, July, August and September) shows almost equivalent concentrations during daytime and night time. The April and October shows similar trend as of winter months, however with lower magnitude of concentration. The effect of monsoons and metrological parameters has been also analysed. The precipitation (rainfall due monsoons) lowers the levels of PM2.5 concentration. The PM2.5 concentration is positively and negatively co-related with the wind speed and temperature. The AQI is good during the months of July and August and in the winter months is quite unhealthy. The exceedence factor (EF) of PM2.5 suggests that NCT/Delhi was critically polluted during both the years.

Keywords: Particulate Matter; Air Quality Index; Meteorological Parameters; Control Measures

Introduction

Clean air is essential for sustenance of life in the terrestrial environment of the earth. Air pollution is a major issue which needs to be focused globally and demands well-planned strategies to protect and control the pollution levels that are based on current scenario of pollution. Rapid increase in population, urbanization and industrialization is globally responsible for emission of harmful gases in the atmosphere such as oxides of carbon, nitrogen, sulphur and particulate matters etc. [1] These gaseous emissions not only degrade the quality of atmosphere but are also responsible for climatic changes. Further, it has been found that the global climatic changes are responsible for ecosystem degradation. [2] The composition of air can be altered by a number of factors which are broadly categorised as natural or man-made 'anthropogenic' activities. [3] Volcanic eruptions, dust, forest fires, out gassing of soil, thunderstorms etc. are a few sources of air pollution that are caused naturally. Emissions from the industries, vehicular mobilization, flash ash, land fill dumped with disposed waste are regarded as some of the anthropogenic sources, which are usually centred around human life and broadly observed as stationary sources [3]. One of the major classes of air pollutants are classified by the particulate size of the pollutant known as 'Aerosol or PM (particulate matter)' [4]. They may be classified as primary aerosols that are directly pushed into the atmosphere or secondary aerosols that are formed due to gas particle processes. [5]. Their formation and hence the effects are quite complex. For instance, some volatile gasses generated from anthropogenic or natural process might get condensed over the surface of pre-existing primary or secondary aerosol particles, resulting in reactions inside or over the surface that finally changes its composition [5]. Depending upon the size of the aerosol particles, they are often classified under three modes. First - 'the coarse mode' in which particle size is above 1μm [4]. Second is - 'the accumulation mode' whose particle size is in range from 100nm to 1μm and third is, 'the nucleus mode' whose PM size is less than 100nm. In general PM*x* is the representation of aerosols with diameters $< x\ \mu m$. With urbanization and fast changing economy of the society, the rapid rising levels of aerosol particles, in particular PM2.5 is quite alarming as they play a key role in changing climatic/weather conditions on global/local spatial scales [6, 7, 8] have reported seasonal changes over the Delhi. They observed variations in PM10, PM2.5 and PM1collectively as 20-180μg/m^3 and 100 - 500μg/m^3 during the monsoon and winter season respectively. They have also reported that the concentration of particulate matter shoots up anomalously upto ~1200μg/m^3 due to firework festivals [9]. It has been also established that the relative increase in humidity elevates the level of suspended particulate matter when compared with ambient air quality on normal days. Even the suspension of PM2.5 and PM1 remain in air for several weeks due to non-linear processes and is least affected by monsoon at these sizes of aerosols [9]. According to [10] PM emission from urban areas contributes less than 15% to the urban background. Due to traffic sources, the emission concentrations of elemental carbon, heavy metals from tyre wear and tear and carbonaceous particles are ~3 times higher in street canyons. Also, about 70% of organic compounds comprises of carbon from modern sources and 30% from combustion of fossil fuel.

They also have hazardous health impact and disturb the radiation balance of the atmosphere [6, 7, 11] states PM2.5 as one of the most harmful air pollutant. Several adverse health impacts for the aforesaid range of particulate matter were widely stated by World Health Organisation [12]. According to WHO, an increase in total PM concentration by ~10μg/m^3 per year increases the mortality rate by 6%. Even a little exposure to the increased level of PM (10, 2.5, 1) for several days is sufficient enough to elevate cough, respiratory diseases like asthmatic and cardiopulmonary attacks, and even death in some cases [10, 12, 13]. Since the PM2.5 and PM1 in the air are lighter than PM10, they harshly impact the health more than larger particles (PM10) and therefore, it is more important to measure PM2.5 than PM 10 [14]. Polluted air is found to cause almost 16% of global deaths [15]. Wide ranges of environmental toxins are found in urban environment which is a result of urbanization and industrialization over the last 200 years [16, 17, 18].

The elimination/accumulation and the dilution/diffusion of PM2.5 are also affected by meteorological parameters. Stagnant weather conditions like high humidity, accelerates the accumulation of PM2.5 concentrations [19, 20] studied co-relation between meteorological parameters and PM2.5 over the United States and emphasised the role of meteorological parameters in mass accumulation of PM2.5. [11] have reported that the favourable meteorological parameters can reduce the accumulation of PM2.5 mass concentration by 16% over the roadside. [21] assessed the effects of meteorological parameters over Nagasaki. They found that PM2.5 is positively and negatively correlated with temperature and precipitation respectively. They also reported that the westward wind was responsible for transport and accumulation of PM2.5 during all the seasons.

Delhi being one of the largest urban areas in the world [3] serves as residential and commercial hub for nearly 16.3 million people [22]. The NCT Delhi has population density of ~ 11,297/km^2 with decadal growth rate of 20.96 % [22]. Thus, the elevated levels of pollutant make the situation graver. Delhi is the capital of India and spans over an area of 1483km^2 [23]. It adjoins other states like Haryana, Punjab, Uttar Pradesh and Rajasthan, thus behaving as a central point of urban agglomeration. Thus, it is necessary to continuously monitor and control the air quality of the Delhi and National Capital Region (NCR). For monitoring and quality check of the air in India, various organisations at state and central level - Delhi Pollution Control Committee (DPCC) and Central Pollution Control Board (CPCB) have set standards of various air pollutants. These standards vary in each country. The representations of these standards are given by Air Quality Index (AQI). The AQI is the index for monitoring and reporting the air quality. As per the AQI issued by CPCB, the levels of PM2.5 from 0-50μg/m^3, 51-100μg/m^3, 101-200 μg/m^3, 201-300 μg/m^3, 301-400 μg/m^3, 401-500 μg/m^3 have been designated as good, satisfactory, moderately polluted, poor, very poor and severe pollution, respectively.

In the present work, an attempt to study the distribution of PM2.5 on different temporal scales that includes - monthly, daily, diurnal variations have been analysed statistically. To study the effect of metrological parameters on the distribution of PM2.5, various parameters - precipitation due to monsoons, temperature and rainfall have been statistically analysed. The earlier reports existing in the literature mainly focuses on the health impacts, sources and challenges associated with PM2.5. From these reports we understand the impact and adversity of finer particulate matter on biosphere, namely PM2.5, thus understanding its distribution, analysing it statistically to predict its behaviour is need of the hour. Thus, more statistical and analytical analysis is required for mitigating its effects on a region with population density ~11000/km^2 [22].

Study Region and Data Source

The NCR of Delhi covers an area of about 34000 Km^2 in the territorial jurisdiction of four state governments namely, National Capital Territory of Delhi, Haryana, Uttar Pradesh and Rajasthan [23]. The National Capital territory (NCT) of Delhi covers an area of 1483Km^2 whereas the states such as Haryana, Uttar Pradesh and Rajasthan contributes an area of about 13,428, 10853 and 8380 Km^2 respectively [23]. NCT of Delhi is comprised of various topographical features such as extension of the Aravali Ridges, rivers like Ganges, Yamuna and Hindon and fertile agricultural land. The estimated rural urban population in Delhi NCT is about 46 millions [23]. Delhi has the latitudinal limit of 28°24'17' and 28°53'00' N and longitudinal limit of 77°21' 30' and 77°45' 30' E [23]. For the present study, the data of PM2.5 for years 2016 and 2017 over the Delhi NCR has been taken from https://in.usembassy.gov/embassy-consulates/new-delhi/air-quality-data/. The data of metrological parameters for the study period has been from https://www.weatheronline.in/.

Results and Discussions

In this section the monthly, daily and diurnal distribution of PM2.5 over the study region has been analysed during year 2016 and 2017. The effect of monsoons on PM2.5 has been studied by comparing the pre-monsoon, monsoon and post-monsoon periods. Also, the effect of metrological parameters - wind speed and temperature over PM2.5 concentration has been discussed.

Monthly variation of PM2.5 in Delhi NCR

Figure 1 represents monthly variation of PM2.5 during year 2016 (red) and 2017 (grey). The concentration of PM2.5 varies from ~30μg/m^3 to 300μg/m^3 in year 2016 and ~30μg/m^3 to 270μg/m^3 in year 2017. It is observed that the mass concentration of PM2.5 is almost equivalent in both the years. The concentration of PM2.5 is found to be higher in the winter season (November, December and January) compared to the other seasons. The minimal concentration of PM2.5 is observed in the month of July and August (Monsoon season). During monsoon season the concentration of PM 2.5 is found to be good as per the Air Quality Index (AQI) standards. According to the AQI classification, month of January and December is found very unhealthy in terms of air quality in both of the year except January, 2017. The months from June to September are found good in terms of air quality, while the months from March to May are found to be satisfactory in terms of air quality (~70μg/m^3 to 80μg/m^3) in both of the year [24].

The quality of air is designated as critically, highly, moderately and lowly polluted as per the exceedence factor (EF). The EF is defined as the ratio of annual mean concentration of a pollutant with their respective standards. The four categories are:

1. Low Pollution (L): EF<0.5
2. Moderate Pollution (M): 0.5≤EF<1.0
3. High Pollution (H):1.0≤EF<1.5
4. Critical Pollution (C): EF≥1.5

As per the data analysis the EF levels of PM2.5 was much higher than 1.5 in both the years which implies that Delhi was critically polluted during both the years. Table 1 represents the EF levels over Delhi.

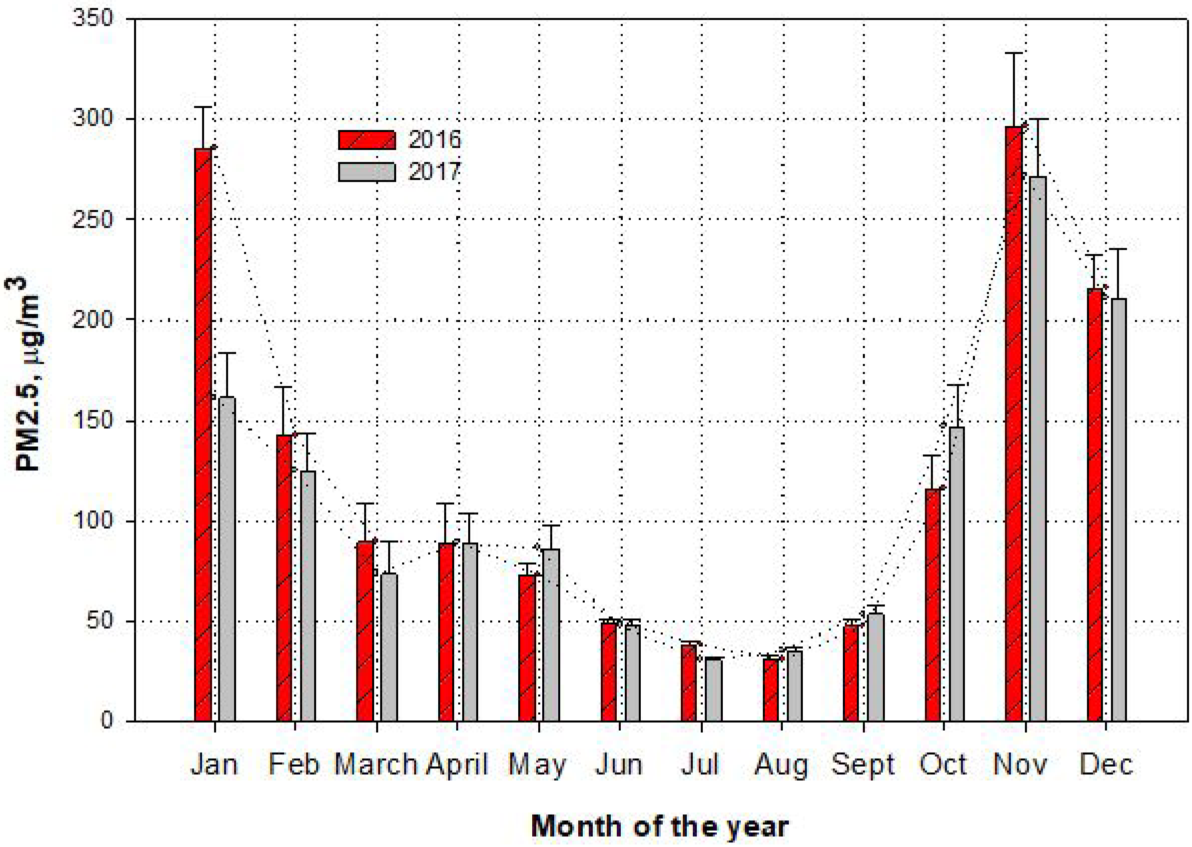

Figure 1: Monthly variation of PM2.5 with standard deviation during year 2016 and 2017

Year	PM2.5 (µg/m^3)	Exceedence level (EF)	Pollution Type
2016	122.67	2.45	C
2017	110.75	2.21	C

Table 1: Exceedence Levels (EF) in Delhi

3.2 Daily variation of PM2.5

For more precise and in depth understanding of PM2.5 distribution, day wise concentration of PM2.5 is considered in present study. Figure 2 represents the day wise PM2.5 concentration for the years 2016 and 2017. The variation in mass concentration of PM2.5 is found almost similar in both of the year, however significant differences in their daily concentration is evident. The highest concentration of PM2.5 i.e. ~642µg/m^3 and ~600µg/m^3 are found on 308th and 311th day, in year 2016 and 2017 respectively. The lowest concentration of PM2.5 i.e. ~10µg/m^3 and 9µg/m^3 are found at 234th and 211th day in the year 2016 and 2017 respectively. It is observed that the PM2.5 concentration is higher in the beginning of the year and further decreases as the year progresses and in the months of the summer PM2.5 is almost constant in terms of mass concentration. Thereafter, the concentration of PM2.5 further decreases and attains lowest value during the monsoon season. The PM2.5 concentration further increases gradually in the month of September and increases abruptly in the month of November, December and January in both of the years. PM2.5 is found highly variable in winter i.e. ~600µg/m^3 to 100µg/m^3 in both of the years, emphasizing the influence of some prevalent local conditions. There are few days in summer months in which the values of PM2.5 are much higher than average normal trend in both the years. This could be attributed to local dust storms. NCT/Delhi comes under semi-arid region and often experiences dust storm during summer months.

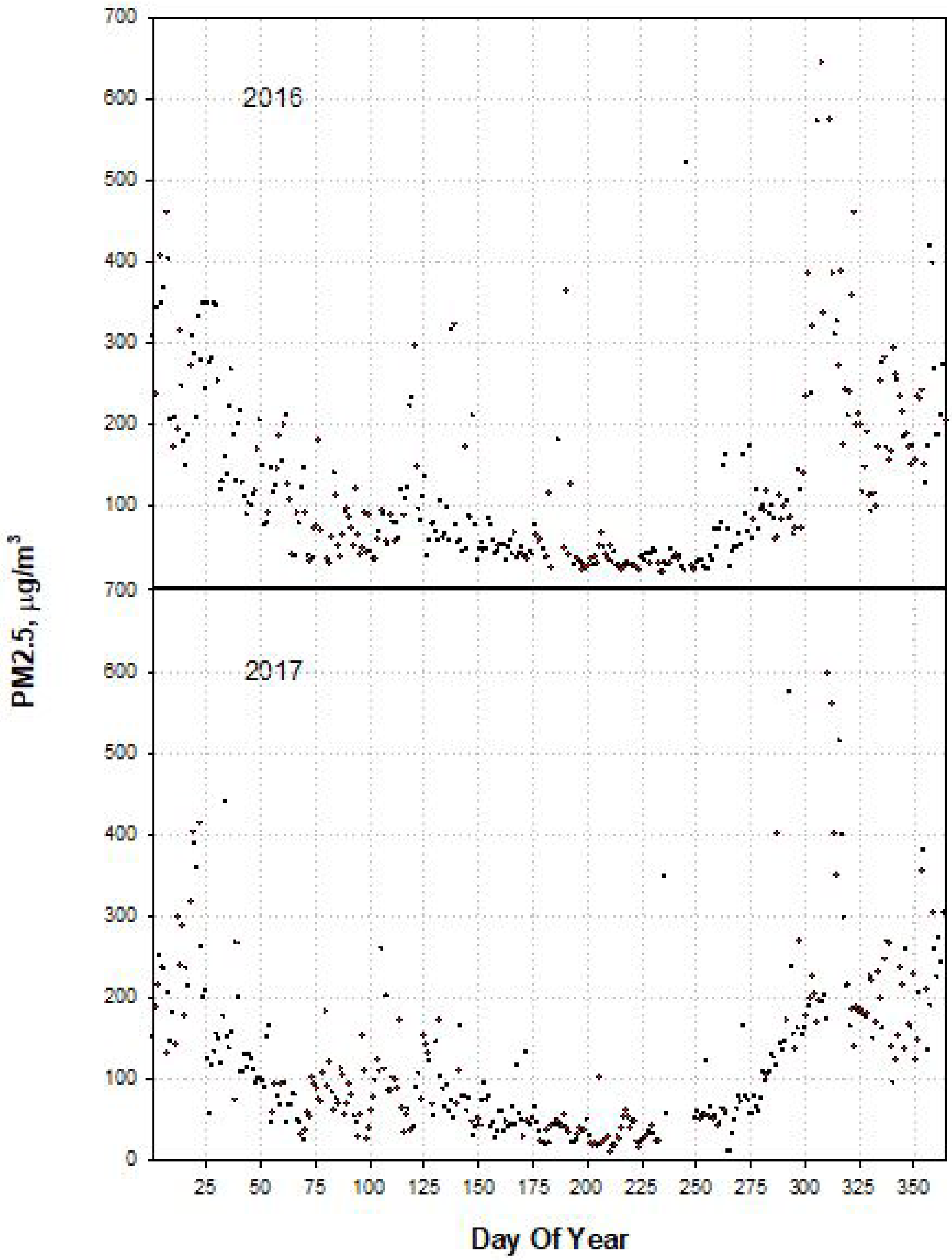

Figure 2: Daily variation of PM2.5 during year 2016 and 2017

3.3 Diurnal variation of PM2.5

Figure 3 represents the diurnal variation of PM2.5 concentration during each month for the year of 2016. In the month of January the maximum concentration of PM2.5 is observed during the day time (10 LT; 330µg/m^3). Afterwards the value of PM2.5 decreases to 210µg/m^3 till 17 LT thereafter, increases till 22 LT. Similar diurnal variation is observed from February to May with lesser magnitude of PM2.5 than the January. Some abrupt increment in PM2.5 concentration is also observed in the month of March at 12 LT and 16 LT. June to September months are found to be good in terms of air quality as the diurnal variation of PM2.5 is almost constant throughout the day and night with lower mass concentration i.e. < 50 µg/m^3. A rising trend in PM2.5 is observed from October onwards till December and characterised with unhealthy air quality.

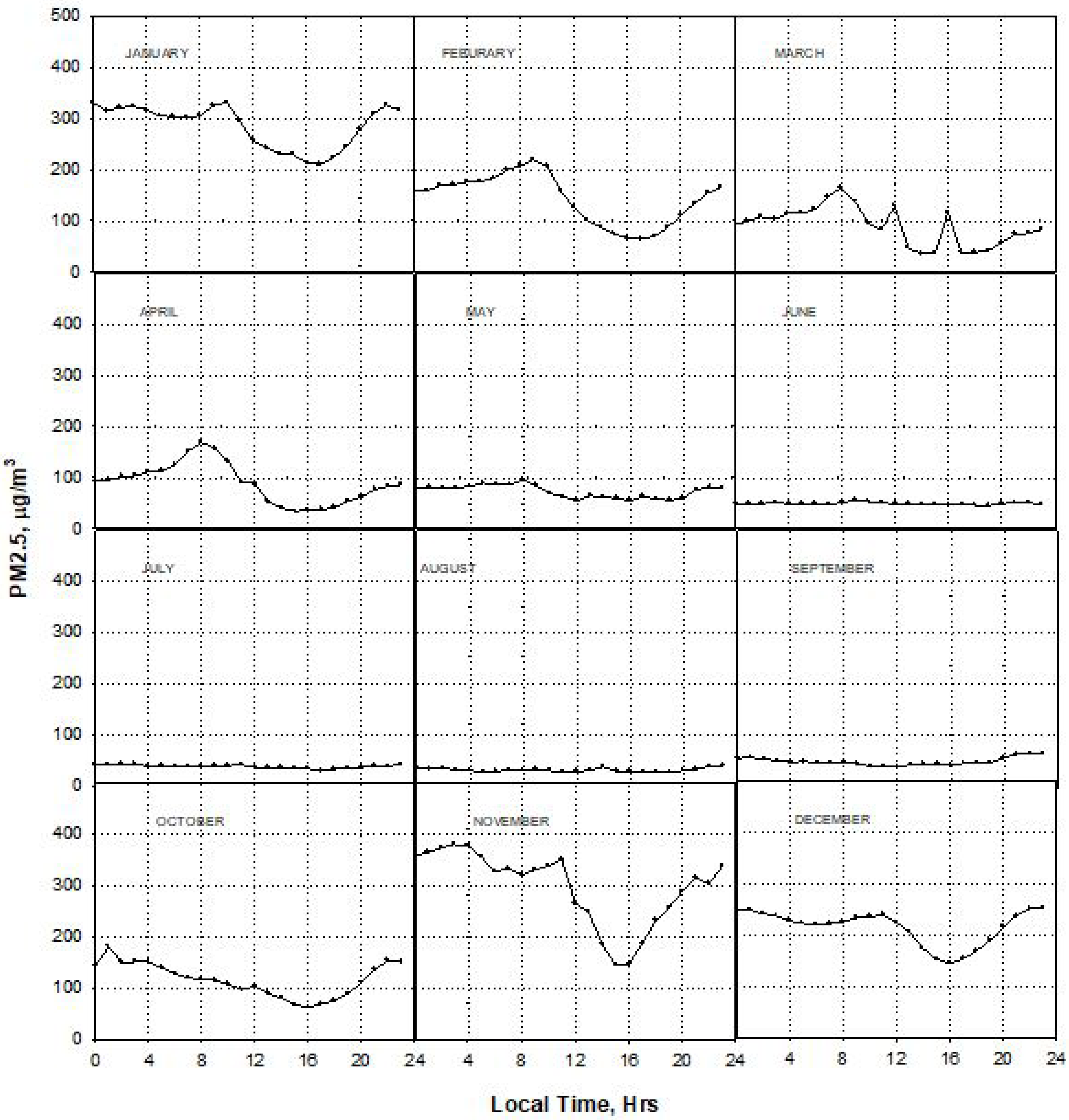

Figure 3: Diurnal variation of PM2.5 during each month in year 2016

Diurnal variation in PM2.5 for the year 2017 is presented in figure 4. Similar diurnal features of PM2.5 are found from January to May, which shows decrease in the PM2.5 concentration after daytime peak. The daytime peak is around 9 LT during January and February; 8LT in March. The decrease in the mass concentration is observed till 17 LT; thereafter it increases during the night until day time maxima is reached [25]. In the month of April and May the diurnal features are not vivid; some abrupt peaks are observed during the afternoon/evening. In general these months show higher mass concentration during the nighttime compared to daytime. The months of June, July, August and September show almost constant values during the day and nighttime. Also, the AQI is also satisfactory. The monsoon months July and August have good air quality. The PM2.5 concentrations start rising again from the month of October. The moths of October, November and December show similar diurnal features as of January. These months also shows maxima during the daytime, thereafter it decreases till evening minima is reached, then increases all through the night sector.

The general trend of months - January, February, March, October, November, and December emphasizes higher mass concentration of PM2.5 during the night time compared to daytime in both the years. The monsoon months show little/no variation in the PM2.5 mass concentration during day and night time and shows good AQI. The AQI of the summer months is satisfactory and the daytime values of PM2.5 and greater than nighttime in year 2017.

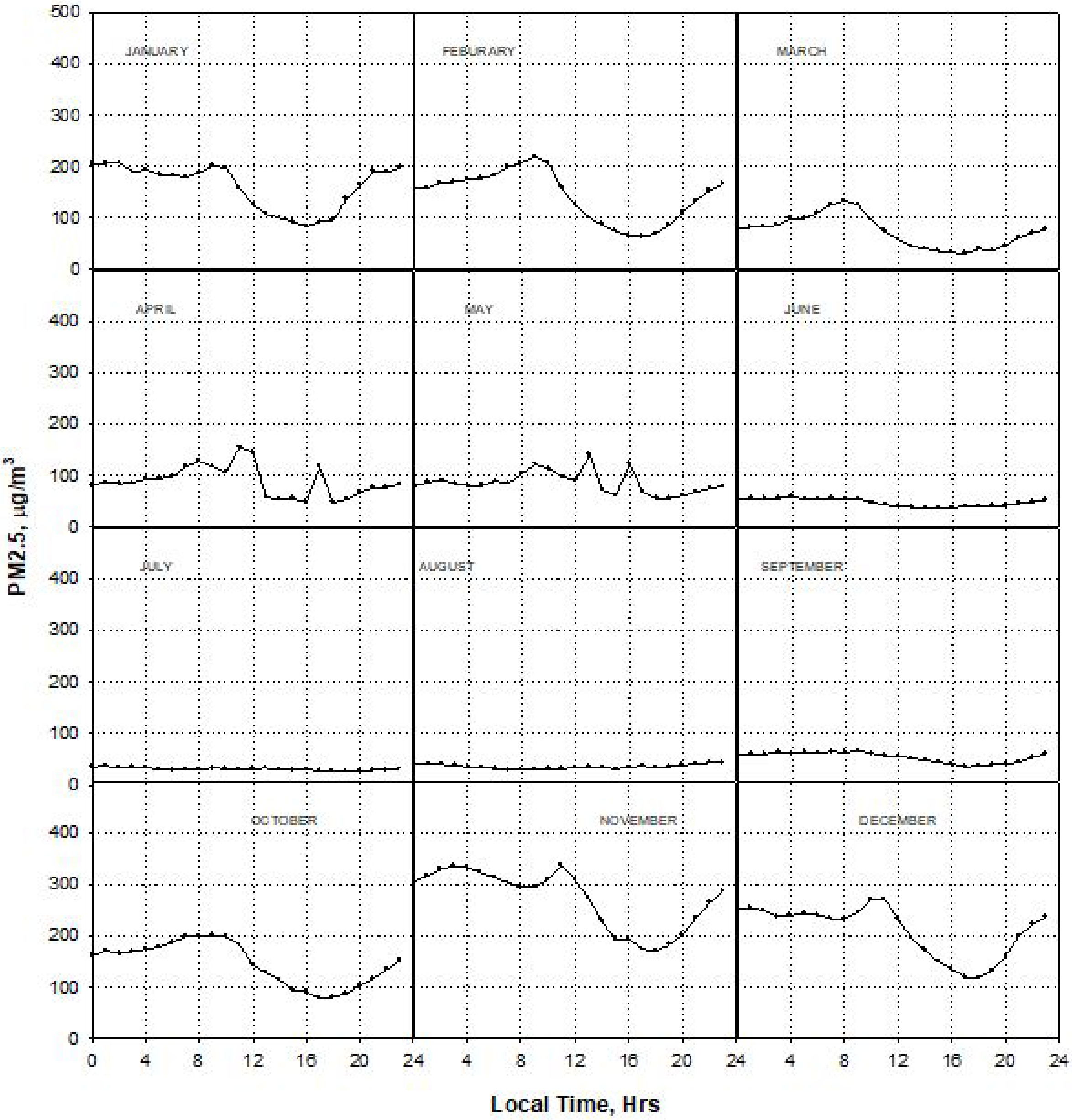

Figure 4: Diurnal variation of PM2.5 during each month in year 2017

Effect of Monsoons

To study the effect of monsoon on the concentration of PM2.5, we have analysed the diurnal variation of PM2.5 during pre-monsoon (March, April and May), monsoon (Jun, July and August) and post monsoon (September, October and November) seasons for year 2016 and 2017. Figure 5 shows the variation of PM2.5 during pre-monsoon, monsoon and post monsoon seasons for year 2016 and 2017.

In both the years, it is observed that the PM2.5 concentration is minimum and maximum during monsoon and post monsoon seasons. During the monsoon season, PM2.5 remains ≤ 50 μg/m³. This clearly illustrates the scavenging effect of the rainfall highlighting its role in lowering the particulate matter concentration. Tiwari et al., 2012 studied the mass variation of PM10, PM2.5 and PM1 during monsoon and winter season. They also found the concentration of particulate matter reaches its annual minimum during monsoons. The particulate matter concentration is lowest as the wet removal process is quite effective during this process.

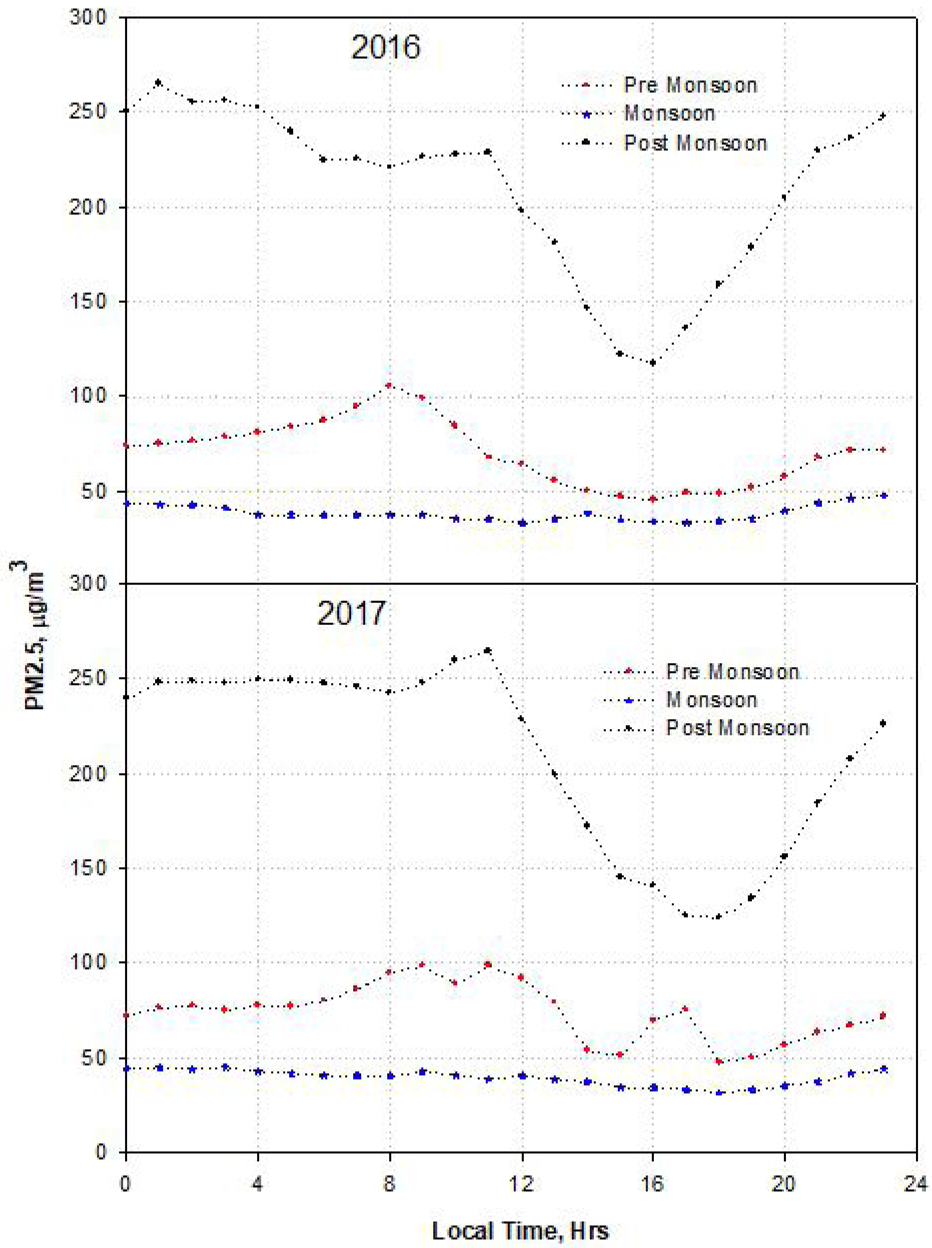

Figure 5: Diurnal variation of PM2.5 during pre-monsoon (red), monsoon (blue) and post monsoon (black) in year 2016 and 2017

From the month of October the scenario changes as the rainfall decreases. The post – monsoon season is dry and with the advent of the cold weather the mass concentration of PM2.5 starts increasing. The month of November experiences huge increase in the concentration of PM2.5 due to Diwali cracker and fireworks. During post-monsoon the PM2.5 concentration from 0-11LT remains high and almost constant. Thereafter, it decreases till ~16LT (2016) and ~ 18 LT (2017) and then again increases till 23 LT. After that it remains almost constant. The pre-monsoon period shows a daytime peak ~ 8 LT (2016) and ~ 18 LT (2017). It falls thereafter and again increases during the night. A general trend observed during pre and post monsoon season is that the PM2.5 concentration peak is observed during the daytime. However, the average PM2.5 concentration values are higher during the night time compared to daytime. The effect of rainfall on the concentration of PM2.5 is quite evident from the present observation (figure 5) and discussion. The effect of other metrological parameters – temperature and wind are discussed below.

Effect of Temperature and wind speed on PM2.5

The PM2.5 has adverse effect on human health and climatic conditions on local as well as on the global scale.

The meteorological parameters like wind speed, temperature, relative humidity, precipitation etc. affect the diffusion and dilution rates of the particulate matters.

In the present analysis, we have chosen two major factors- temperature and wind speed. Fig. 6 exhibits the annual variation of PM 2.5 with wind and temperature. Figure 6 shows variation of PM2.5 (red), wind speed (black), temperature (blue) in year 2016 and 2017, respectively.

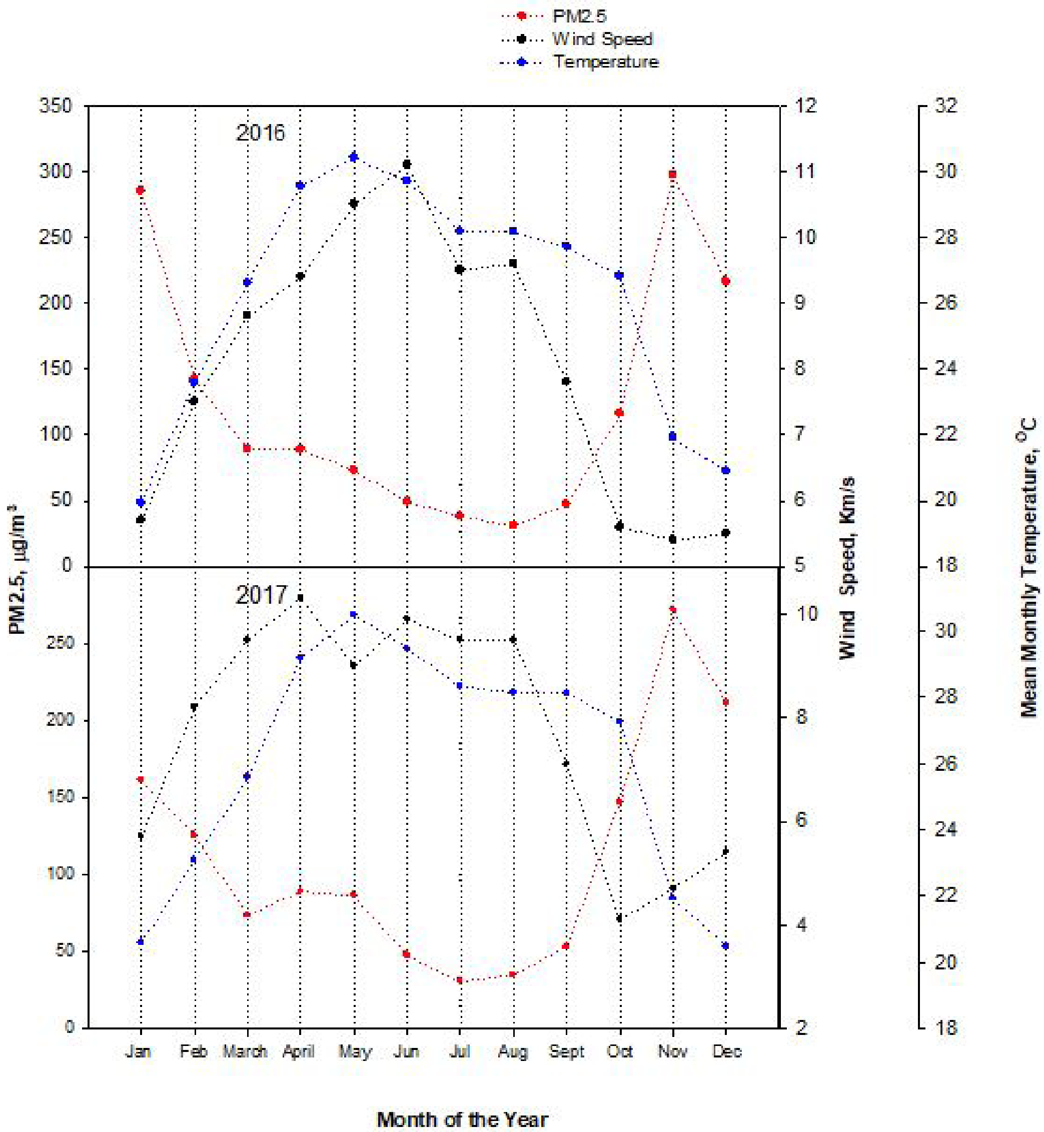

Figure 6: Variation of PM2.5 (red), wind speed (black) and mean monthly temperature (blue) during year 2016 and 2017

Effect of temperature

It is observed that the variation pattern of PM2.5 and temperature are opposite to each other. As the temperature increases, the value of PM2.5 decreases and vice-versa. It is seen in the winter season (November, December and January) that the values of PM2.5 is ~200-300µg/m³ in year 2016 and ~160-270µg/m³ in year 2017. The temperature during winters is ~19-23˚C in the year 2016 and ~20-23˚C in the year 2017. During the spring time (February and March) the temperature is ~25˚C and the observed concentration of PM2.5 is ~120µg/m³ in year 2016 and ~100µg/m³ in year 2017. In the summer season (April, May, June) when the average temperature is ~30˚C during both the years, the PM2.5 is ~75µg/m³. During monsoon and post monsoon (July, August, September, and October) the values of PM2.5 goes down and is ≤50µg/m³. As per Air Quality Index (AQI) issued by Central Pollution Control Board (CPCB), India the values of PM2.5 ≤50µg/m³ is satisfactory. Hence, it can be inferred that the precipitation/rainfall during monsoon season helps in reducing the level of PM2.5 during monsoon and post-monsoon period. Figure 7(a) exhibits correlation between PM2.5 and temperature. It shows negative and linear relationship with the correlation factor of R^2=0.8 in year 2016. The concentration of particulate matter PM2.5 with temperature in year 2017 also shows linear and negative correlation, R^2=0.61 (Figure 7(b)). From the present analysis it is evident that PM2.5 increases as the temperature decreases and vice-versa. The particulate matter PM2.5 accumulates at a faster rate during low temperature. December/January experience coldest weather conditions, however, it is seen that in the month of November has highest value of PM2.5 in both the years. This could be due to festive season - burning of crackers and crop residue burning as major contributors.

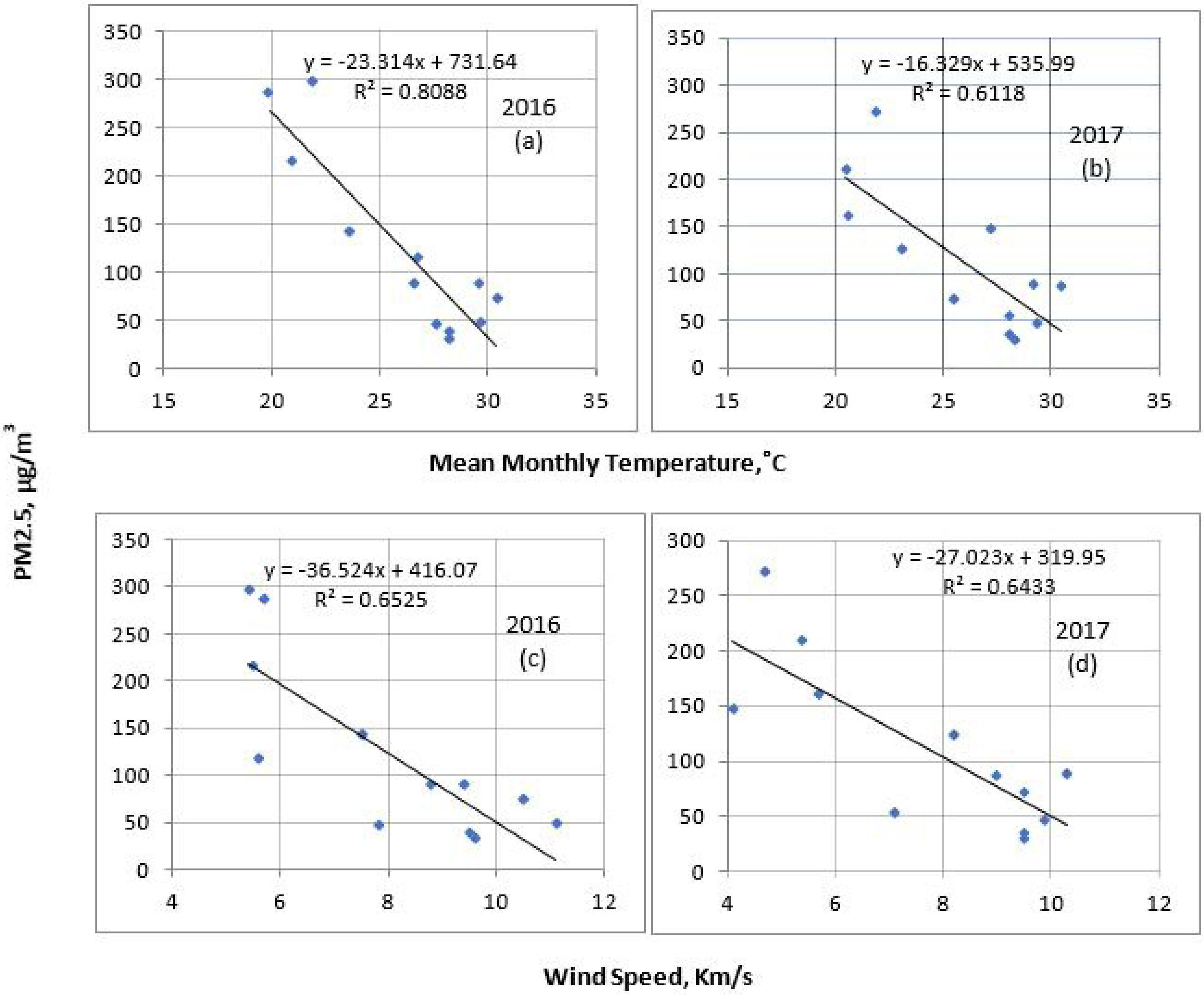

Figure 7: Relationship between PM2.5 with monthly mean temperature (2016-a, 2017-b) and with wind speed (2016-c, 2017-d)

Effect of Wind Speed

Air circulation and wind speed affects the concentration and the diffusion rates of the particulate matter. The increase of wind speed also helps in displacing the particulate matter locally on the spatial scale. In Delhi NCR the wind speeds are generally low, thus the levels of PM2.5 are quite high. In the present analysis, it is seen that the increase in wind speed helps in reducing the levels of PM2.5 in Delhi, NCR. During the winter season (November, December and January) that the values of PM2.5 are ~200-300μg/ m^3 in year 2016 and ~160-270μg/m^3 in year 2017. The wind speeds are quite low at this time. It is ~ 5.5km/s in year 2016 and ~5 km/s in year 2017. During the spring time (February and March) the wind speed is ~ 7.5 to 8.5 km/s in year 2016 and 8.5to 9.5 km/s. The observed concentration of PM2.5 is ~120μg/m^3 in year 2016 and ~100μg/m^3 in year 2017 in spring time. In the summer season (April, May, June) when the average wind speed is ~10 km/s during both the years, the PM2.5 is ~75μg/m^3. The wind speed keeps on decreasing gradually in months of July, August, Sept and October from ~9.5 to 5.5 km/s in year 2016 and from ~9.5 to 4 km/s in year 2017. During monsoon and post monsoon (July, August, September, and October) the values of PM2.5 goes down and is ≤50μg/m^3. These low values are more attributed due to precipitation/rainfall rather than wind speed or temperature. The PM2.5 with wind speed shows negative linear relationship with co-relation coefficient R^2=0.65 (figure 7(c)) and R^2=0.64 (figure 7(d)) in year 2016 and 2017 respectively.

From the present analysis it is quite evident that the metrological parameters - temperature and wind speeds are linearly and negatively co-related to PM2.5. The lower magnitudes of these metrological parameters support the accumulation of PM2.5. However, these relations change adversely on spatial and temporal scales. Few reporting suggest positive as well negative relation with metrological parameters. Yang et al., (2017) observed negative as well as positive co-relation with Pm2.5 over 74 major cities of China. They have stressed over spatial of heterogeneity with metrological parameters. Wang and Ogawa, (2015) suggested that the correlation between PM2.5 concentration and meteorological data showed that temperature had a negative, and precipitation had a positive, correlation with PM2.5. The average PM2.5 concentration over the northern part of India (region of present analysis) is high ~100-120 μg/m^3, however its secondary reactions results in emanation of various organic/ inorganic toxic aerosols. This serves as major threat on health issues. The accumulation changes with seasons and amount of precipitation. It is observed that precipitation/rainfall brings down the level of PM2.5 during monsoons and post monsoons. However, the levels of PM2.5 are high during rest of the year. The situation worsens as the winter approaches. During the winters the crop residue burning contributes a lot in accumulation of particulate matter. The particulate matter getting involved into secondary reactions contribute to more deadly and harmful pollutants. Thus, during the winters the AQI is highly unsatisfactory and serves a major challenge.

Control Measures

Vehicles: The conventional vehicles should be replaced by electric/hybrid vehicles. For this new residential and commercial buildings should have charging facilities. The diesel vehicles should be equipped with Diesel Particulate Filters (DPF) for retro-refinement. This will highly reduce the PM emissions. With the implementation of Bharat Stage Emission VI (BS-VI), it is expected that PM and NOx emission will reduce. The reduction of NOx emission will help in reducing the secondary nitrates that would further inhibit the production of ozone as a pollutant. The BS-VI norms cut down the NOx emissions (reduced to 25%) for light duty vehicles.

Also as per the BS-VI norms the sulphur content in the complaint vehicles should be brought down to 10ppm. This would reduce the PM emissions from vehicles by about 6%. Timely inspection and proper maintenance of vehicle is required. The automobiles manufacturing company owned service centres (AMCOSC) should be equipped for complete maintenance and inspection of the vehicles ensuing that the vehicles conform to latest/updated emission norms.

The usage of coals in hotels and restaurants should be stopped. The restaurants having higher sitting capacity should shift from coal based appliances to electric/gas based appliances. In the domestic sector, LPG being a cleaner fuel should be widely available for all.

The Construction and Demolition (C&D) waste contribute to dust emissions. The dust emissions are environmental pollutants that have wide range of particle sizes. They cause serious health problems like respiratory issues related to nose and mouth, eye irritation, allergy and infections.

The C&D waste can be managed by wet suppression – water sprinklers should be used for suppression of dust. The wind speed near C&D waste area should be reduced by blockers/shades. The C&D waste on construction site should be covered with ultra thin films/screens to avoid the wide spread of small particulate matter.

The ready mix concrete in the plant batching also acts as a source of particulate matter. The transfer of cement and industrial by – products, such as silica fumes; fly ash etc., collectively called as pozzolan materials to silos is one of the major source for emissions. Therefore, installation of fabric filter is necessary. The raw materials should be handled properly. Wet suppression and wind speed reduction should be employed.

Road dust is another contributing factor. It also adds the concentration of particulate matter. For controlling it, major roads should be vacuumed sweep at least once in a week. Roads should be well maintained and repaired with proper pavements on both sides. To prevent the dust drift during summers, small shrubs should be planted. The open fields should be sprinkled with water. The C&D waste should not be disposed near the road side.

The Biomass/crop burning during winters in Punjab, Haryana and near Delhi regions are major contributors of particulate matter emissions during winters. During winter season the metrological parameters – wind, temperature also favour their concentration. In section 3.5, the effect of wind and temperature is already discussed. The Municipal solid Waste (MSW) is yet another source of particulate matter emissions. Nagpure et al., 2015 reported that in Delhi, almost 190-240 tons of MSW is brunt every day. The Biomass/crop/MSW waste burning should be checked with imposition of fine. These wastes should be decomposed and recycled for biogas generation and remaining slurry/by-products should be used as manure. They can be also used as landfills, as commercial feedstock for cattle. They can be also converted to biochar or used as raw material in industries.

During the festive season of Diwali we have observed that there is huge pile on of particulate concentrations due to cracker bursting. The usage of crackers should be strictly prohibited. The cracker industries should be banned and selling of crackers should be treated as punishable offence by law. Above all these measures, people/citizens should be sensitized through print and social media. In the schools, children should be taught the control measures on basic scale with practical implications. We all should be encouraged and self-motivated to reduce the air pollution.

Conclusions

The analysis of distribution of PM2.5 on different temporal scales - monthly, daily and diurnal over a period of two years (2016 and 2017) have been carried for Near Capital Territory (NCT)/Delhi region. The following points emerge from the present study.

1. The concentration of PM2.5 is highest in winters and lowest in monsoon months.
2. Daily analysis of PM2.5 shows some peaks during summer months which could be due to local dust storms. However, the maxima are observed in winter months during both the years.
3. The diurnal analysis of PM2.5 concentration shows that the winter months show higher concentration of PM2.5 during the daytime compared to the night time. The summer and monsoon months show almost equivalent concentrations all through the daytime and night time. The April and October shows similar trend as of winter months, however with lower magnitude of concentration.
4. The AQI is good during monsoon time. The precipitation/rainfall helps in lowering the levels of PM2.5. The concentration of PM2.5 less than 50 $\mu g/m^3$ in the monsoon months (June, July and August).
5. The metrological parameters affect the concentration of PM2.5. The stagnant conditions favour the accumulation of PM2.5. The temperature is negatively and wind speed is positively co-related with PM2.5 concentration respectively.
6. The EF of PM2.5 suggests that NCT/Delhi was critically polluted during both the years.

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