

Real Time Ambient Air Quality Status during Diwali Festival in Central, India

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Abstract

In India, festivals are celebrated with lot of enthusiasm and Diwali is the major festival of light. In this festival, houses are illuminated by lights and sky is illuminated by fireworks. These fireworks though create lot of amusement but also pollute the atmosphere in terms of air pollution. The continuous air pollution monitoring was undertaken during Diwali festival (2014) at residential site NEERI, Nagpur. Air quality parameters were compared with CPCB standard. On Diwali day, PM₁₀ and PM_{2.5} concentration achieve its highest value of 900 µg/m³ and 950 respectively µg/m³. This high concentration is maintained in atmosphere for two days of this festival in atmosphere which is approximately 8 - 9 times more than that regulatory standard. These particles carry all the components of the cracker including heavy metals, alkali metals, alkaline earth and change the atmosphere with positive and negative ions apart from impaction of sulfur and other acid gases to the atmosphere.

Keywords

PM₁₀, PM_{2.5}, Diwali, Fireworks, Correlation, Regression, Nagpur

1. Introduction

Diwali festival is celebrated in winter season around October, November every year. Due to atmospheric inversion & cold climate, the air pollution load is very high as the pollution load is very high and the pollutants tend to settle down due to low dispersion & dilution in the atmosphere. The urban air quality of India is hereby experiencing increased PM₁₀ concentration. During Diwali festival time, it attains episodic high level in the air quality. The central India which explains land experiences extreme climate during the festival onset of winter is tak-

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en place which ties to settle the air pollutants thus giving lot of exposure to the pollution.

Nagpur is centrally located city in India where industrial and commercial growth is moderate. The city has a population of 46.53570 lakhs (2011 census). It is a big centre for industry, education and agriculture in Vidarbha region of Maharashtra State. The city celebrates Diwali festival in which various types of crackers are burst, which generates lot of air pollution in atmosphere. This may cause episodic rise in PM_{10} and $PM_{2.5}$ in atmosphere and imparts adverse effect on regional visibility, global climate change and health [1].

Daily Standard for PM_{10} and $PM_{2.5}$ is $100 \mu g/m^3$ and $60 \mu g/m^3$ respectively [2]. In urban areas, the air quality largely varies on localities. The air quality of the city mainly depends upon activity going on the city like industrial activity, construction activity, transport activity etc.

In the present study, we intend to observe the immediate and short term effect of various activities like bursting of fireworks performed during the festival season on the ambient air. The CAAMS (Continuous Ambient Air Quality Monitoring System) was installed in the residential area and real time monitor 13th October to 28th October 2014 at NEERI Nehru Marg residential site (Environment S.A.).

2. Materials and Methods

2.1. Study Area

Nagpur ($21^{\circ}15'N$, $79^{\circ}08'E$) is the Capital of Maharashtra in the winter season. The district stretches to almost 9897 sq km. Nagpur is surrounded by plateau rising northward to the Satpura Range, Kanhan and Pench rivers are the two important rivers of the district. It is situated 274.5 m to 652.7 m above sea level and 28% of the town is covered by forest. The city has a typical seasonal monsoon weather which is normally dry. Average relative humidity (RH) is 60%. Annual average temperature ranges from $33.2^{\circ}C$ to $17.1^{\circ}C$ with average annual rain fall 112 mm. The average meteorological parameters during Diwali October 2014 have been monitored by Metrological Department Nagpur (Table 1).

2.2. Methodology

To see the impact of bursting of fireworks during Diwali festival on air quality the real time air quality monitoring was carried out at residential site NEERI, Nagpur (Figure 1) [3]. In the present study ambient air quality was

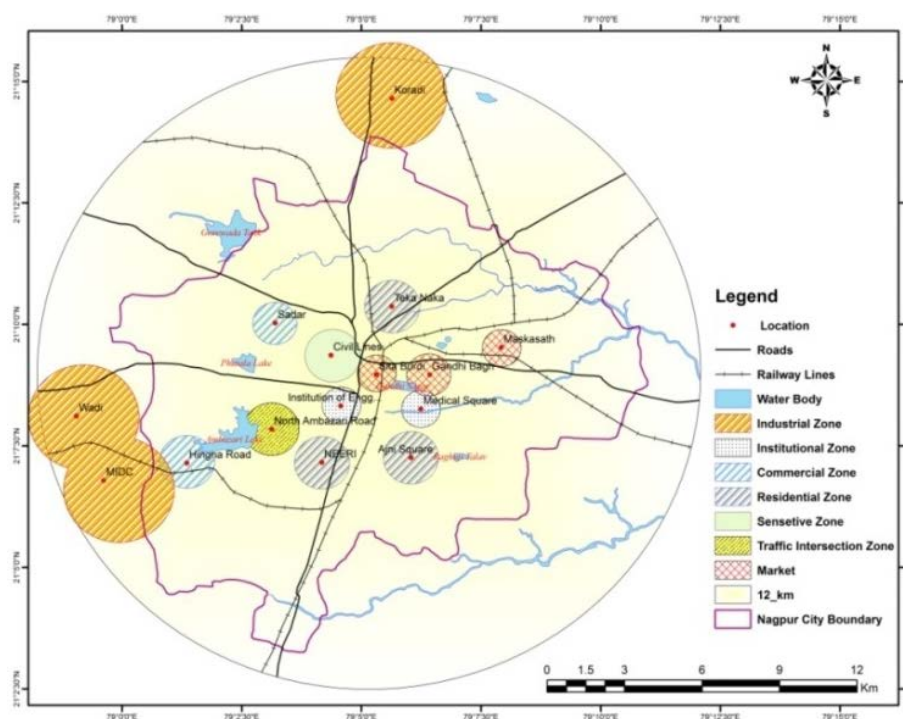


Figure 1. Study area NEERI, Nagpur residential site.

Table 1. Climate data during month of October Diwali.

Date	Temperature (°C)	Wind (m/hr)	Wind Direction (deg)	Humidity (%)	Pressure (mbar)
13/10/2014	27.13	4.25	34° (NE)	35	1012.25
14/10/2014	28.5	4.5	84° (E)	70	1013
15/10/2014	28.63	4	96° (E)	49.13	1012.88
16/10/2014	28.5	3.88	203° (SSW)	72	1008
17/10/2014	27.63	5.38	68° (ENE)	52	1013.38
18/10/2014	28.13	3.25	98° (E)	52	1012.75
19/10/2014	28.5	2.38	119° (ESE)	53.63	1011.75
20/10/2014	28.88	2.13	125° (SE)	52.75	1012.25
21/10/2014	28.88	4	82° (E)	54.63	1014
22/10/2014	27.63	4.25	71° (ENE)	44.50	1014.75
23/10/2014	27.38	2.38	77° (ENE)	44.13	1013.63
24/10/2014	27.38	2.5	130° (SE)	41.38	1012
25/10/2014	24.13	2.88	144° (SE)	66	1014.13
26/10/2014	21.63	1.75	157° (SSE)	80.14	1015.88
27/10/2014	24.75	1.88	241° (WSW)	63.88	1015

measured by CAAMS for fine particulate matter PM₁₀ & PM_{2.5}. The fine particulate monitor of CAAMS works on principle of Beta Attenuation Method for measuring and analysis of the concentration of PM₁₀ & PM_{2.5}. Every hour, a small C₁₄ (Carbon –14 or Krypton 85) element emits a constant source of high-energy electrons (known as beta rays) through a spot of clean filter tape.

3. Result & Discussion

The study of air quality in residential site Nagpur during pre Diwali, Diwali, post Diwali periods was aimed at comparing the air quality during these periods and to find out whether the air quality (PM₁₀ & PM_{2.5}) is within the recommended standard. Diwali is the one of the greatest festival in India that attracts many from far and near thereby increasing human activities like fireworks. NEERI, Residential site was selected for measurement of continuous air quality. The avg. concentration of PM₁₀ and PM_{2.5} has been given in [Table 2](#).

The diurnal variation and the concentration built up in linked to population exposure. The AQI (Air Quality Index) index reaches to dangerous limits indicating heavy impact on respiratory organs of exposed population. The hospital admission also projects alarming rise regarding respiratory disorders.

It is observed that PM₁₀ & PM_{2.5} in the early morning hours (4 AM - 7 AM) and night hours (9 PM - 12 AM) was highest during the festival time ([Figures 2-5](#)). During this time most of the exposed populations are sleeping & hence a large impact on their respiration envisages. These values are approximating 8 - 9 times more than the CPCB standards of PM₁₀ & PM_{2.5} values during festival period [\[4\]-\[9\]](#).

The value ranges between 100 - 900 µg/m³ for both PM₁₀ & PM_{2.5} ([Figures 6-9](#)). This can be attributed by increase in anthropogenic activity such as bursting of Fireworks, transportation, other ritual activities etc. During 7 AM - 9 PM the value of PM₁₀ & PM_{2.5} is relatively less but high as compared to regulatory Standard. The value ranges between 80 - 200 µg/m³ for both PM₁₀ & PM_{2.5}. The episodic increase in the concentration level of fine particulates PM₁₀ & PM_{2.5} reaches the threshold limits for set as 1000 µg/m³ by USEPA which is lately reduced lately [\[10\]](#).

Though the festive period is the time of lot of capital generation for businessmen by selling crackers and sweets, but providing healthy air common people is big question during festival time. In India the air quality standard for PM₁₀ and PM_{2.5} are specified as 100 µg/m³ and 60 µg/m³ respectively [4]. It has been observed that extreme air quality has adverse effects on citizens [11]-[13].

Table 2. Avg. ambient concentration of PM₁₀, PM_{2.5} during Diwali seasons.

Time	Pre Diwali		During Diwali		Post Diwali	
	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)
12AM	117.85	64.485	100.79	342.99	118.65	85.81
1AM	106.31	60.585	107.04	75.98	115.59	87.52
2AM	104.59	62.52	98.98	67.53	104.72	73.92
3AM	105.16	55.22	91.29	58.52	93.95	63.05
4AM	100.30	61.28	383.81	366.44	83.60	55.75
5AM	104.32	65.38	340.82	330.86	74.31	49.90
6AM	94.69	56.64	217.13	195.50	65.52	47.97
7AM	89.44	57.41	138.35	124.09	59.41	42.73
8AM	92.69	57.15	110.88	79.928	55.52	34.09
9AM	112.85	53.85	105.30	64.52	63.69	42.55
10AM	107.37	63.38	105.79	69.43	61.82	42.72
11AM	102.55	53.89	119.32	70.24	62.77	43.23
12PM	90.29	54.33	125.21	73.18	56.41	41.17
1PM	75.90	40.86	108.07	61.72	49.93	29.12
2PM	74.55	36.85	89.69	53.03	56.80	24.62
3PM	68.91	30.48	82.83	45	69.72	33.62
4PM	62.52	37.47	79.27	46.07	70.54	38.20
5PM	69.52	44.81	80.23	33.74	75.81	35.9
6PM	70.28	40.41	72.30	41.16	82.57	49.76
7PM	68.44	42.21	74.40	49.15	92.14	49.08
8PM	85.74	48.32	88.20	53.34	94.53	58.63
9PM	109.08	55.94	107.23	68.19	103.33	59.47
10PM	103.33	63.43	170.38	125.09	106.15	72.99
11PM	97.09	57.31	311.43	245.29	110.12	78.08
Avg. Conc.	92.24	52.68	137.868	114.21	80.32	51.66
AQI	0.92	0.88	1.38	1.90	0.80	0.86

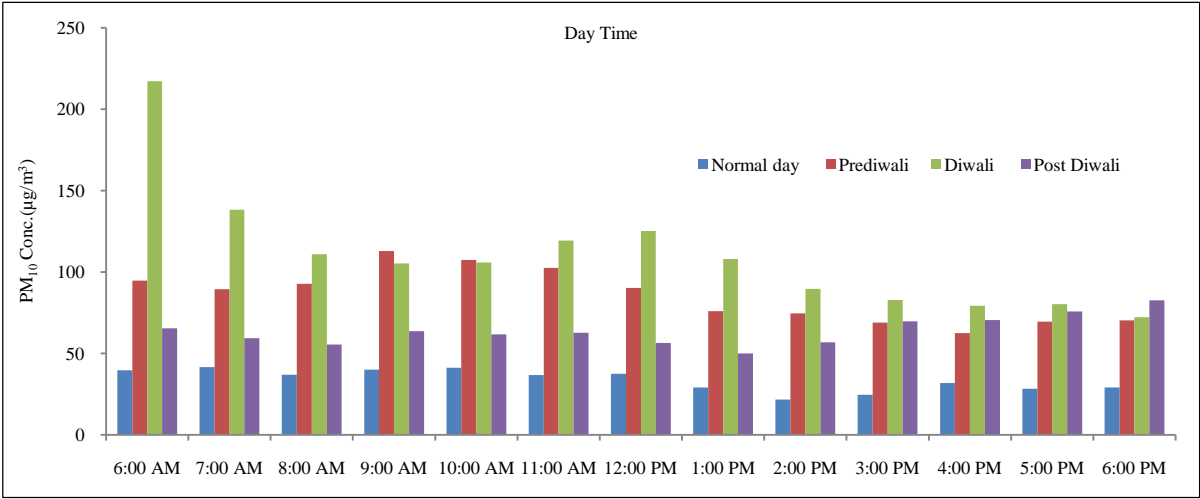


Figure 2. Variation of concentration of PM₁₀ in day time during Diwali days.

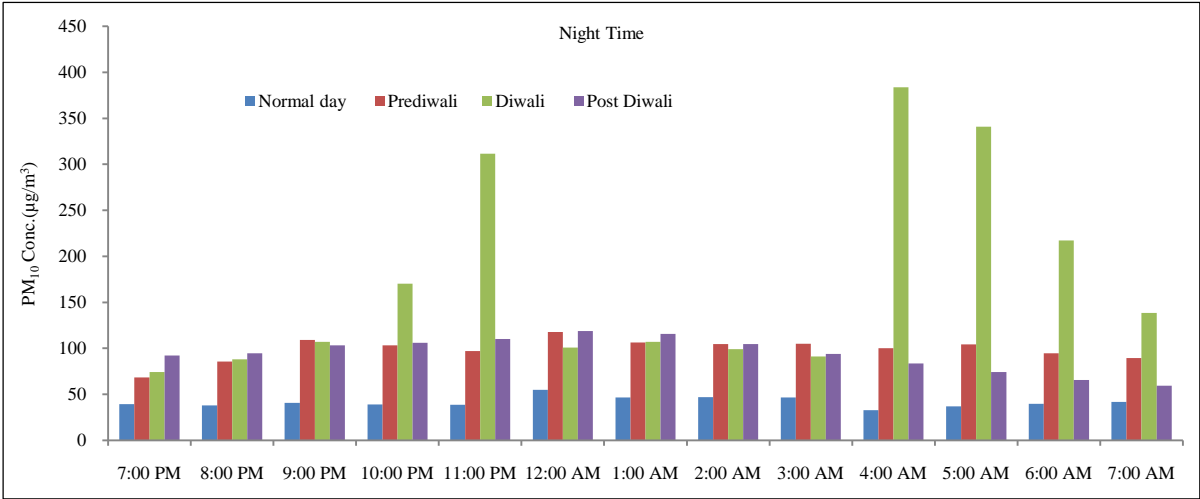


Figure 3. Variation of concentration of PM₁₀ in night time during Diwali days.

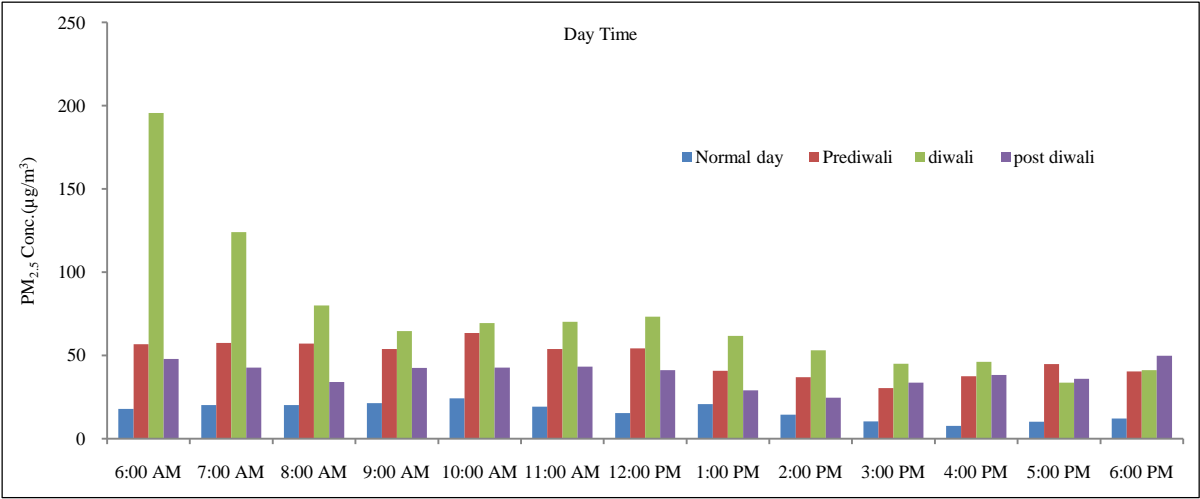


Figure 4. Variation of concentration of PM₁₀ in day time during Diwali days.

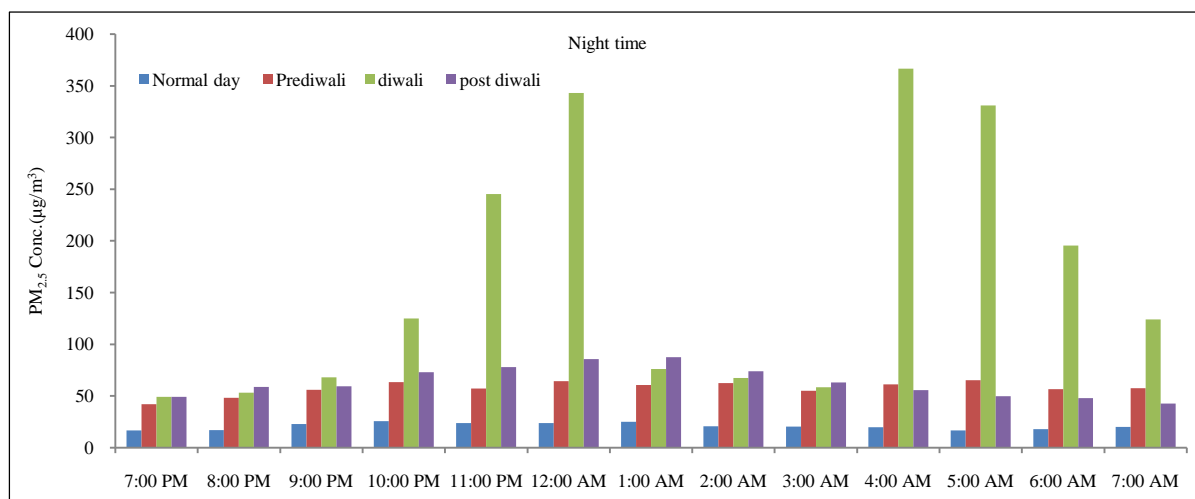


Figure 5. Variation of concentration of $PM_{2.5}$ in day time during Diwali days.

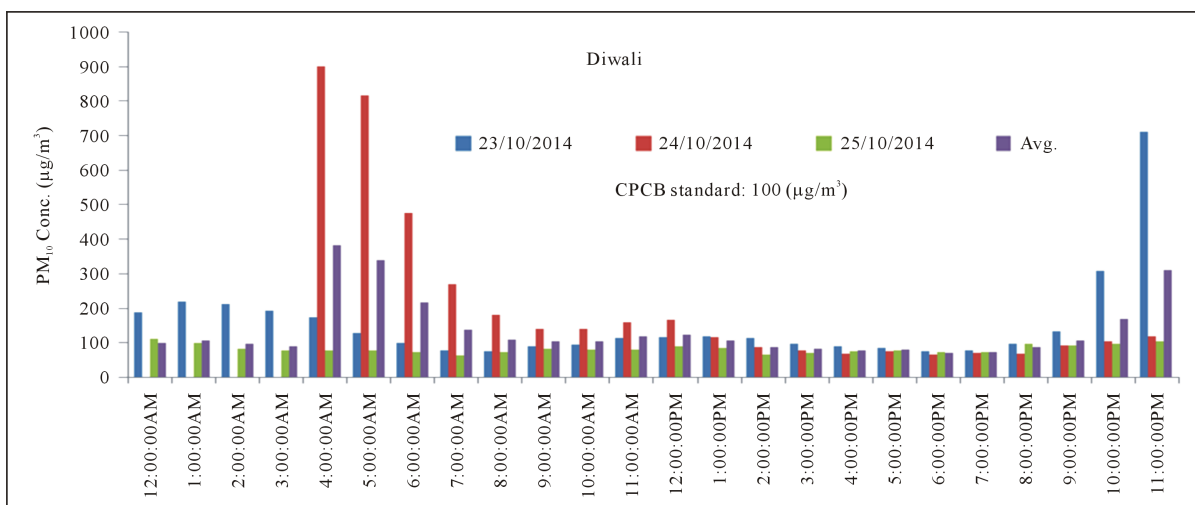


Figure 6. Diurnal variation of PM_{10} during Diwali days.

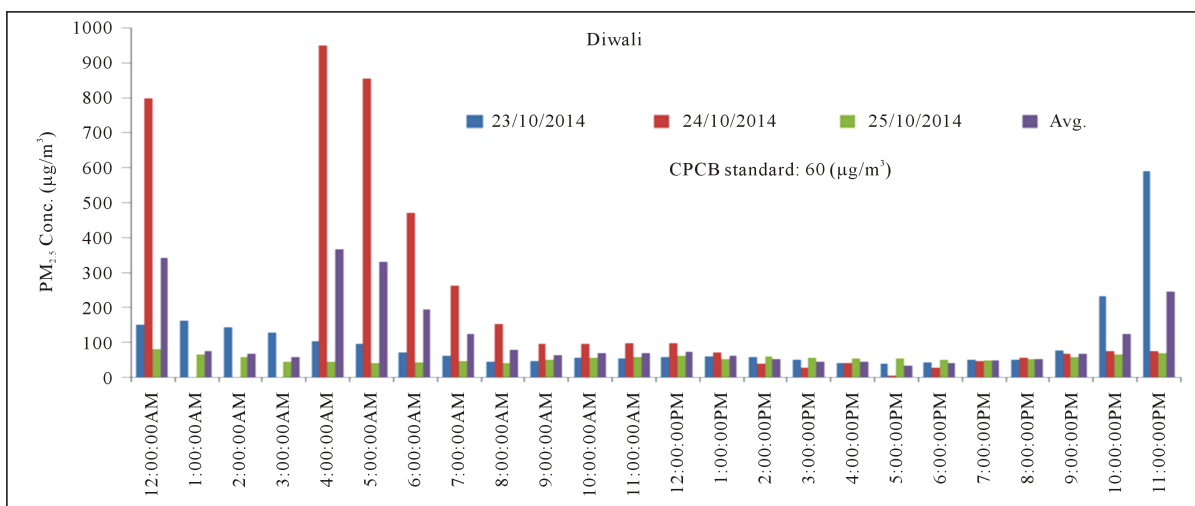


Figure 7. Diurnal variation of $PM_{2.5}$ during Diwali days.

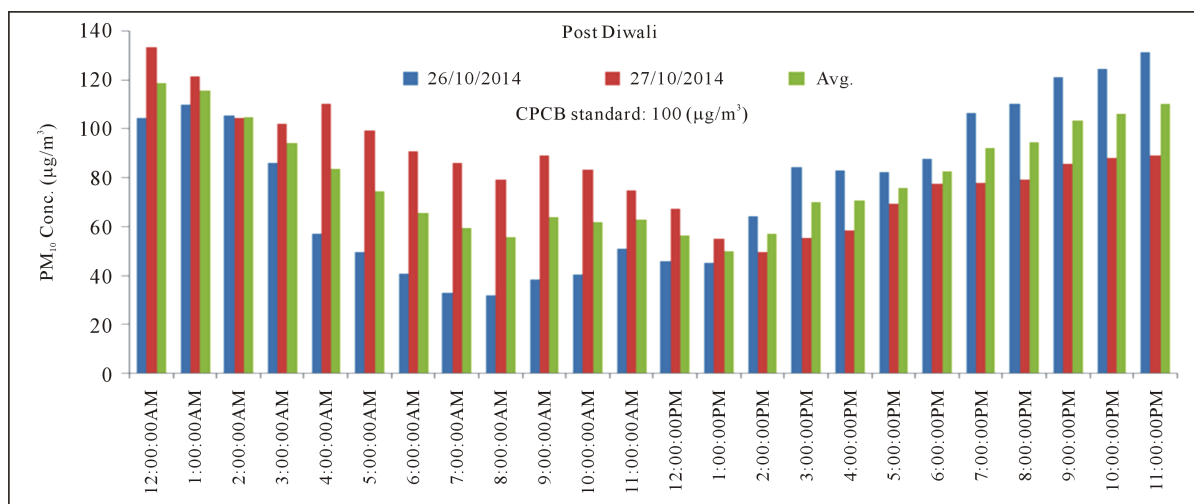


Figure 8. Diurnal variation of PM_{10} after Diwali.

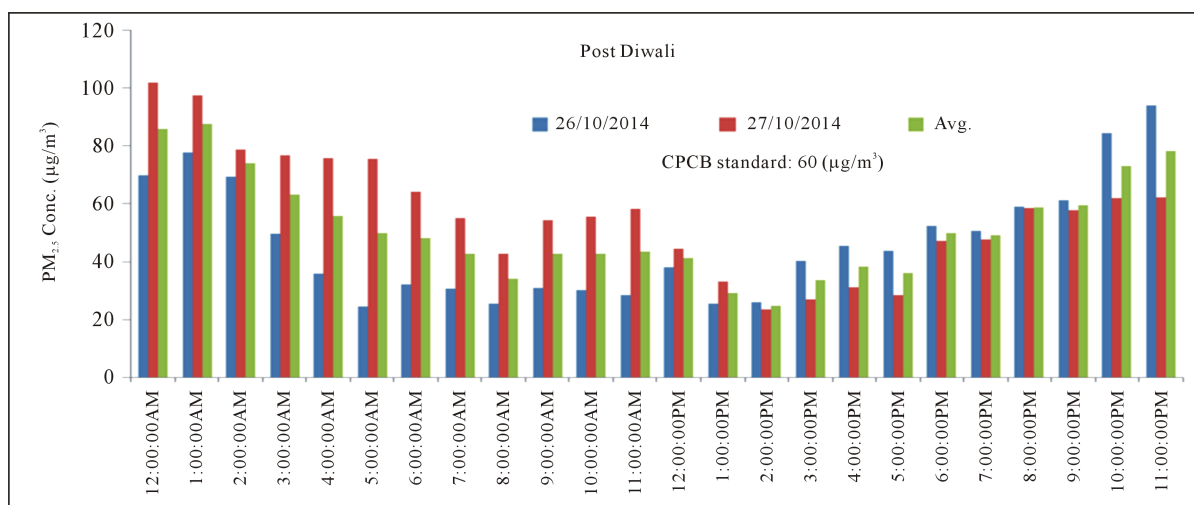


Figure 9. Diurnal variation of $PM_{2.5}$ during Diwali days.

The increase concentration of particulate matter (PM_{10} & $PM_{2.5}$) leads to increase in the cations concentration in atmosphere which causes serious health hazard [14]. Heavy metal characterization is shown in Figure 10 and Figure 11 for PM_{10} and $PM_{2.5}$ respectively. It has been scientifically proven that particulate matter (PM_{10} & $PM_{2.5}$) more than standard value can cause acute respiratory effect [15] [16]. The quality of life of people is well being described by individual's health [17]. Health includes physical, psychological and social well being of an individual [18]. The statistical tool SPSS is used to analyze the data; correlation coefficient and regression coefficient were performed between pollutants PM_{10} and $PM_{2.5}$. The summary of ambient air pollutant is presented in Table 3, Table 4, and Table 5. It has found that ambient air quality in terms of PM_{10} and $PM_{2.5}$ has drastic change as compared to normal (correlation coefficient = 0.6). Even in the post Diwali the condition of air quality is bad. It is negatively correlated with the normal in day time where as the condition is far better in night time during post Diwali days.

It was observed that linear regression of PM_{10} and $PM_{2.5}$ has strong relationship during day time ($R^2 > 0.9$). In the night time PM_{10} & $PM_{2.5}$ has moderate relationship ($R^2 > 0.5$).

Diwali festival is generally celebrated in month of October-November. The meteorology of these seasons is falls in calm condition which may have substantial impact on ambient concentration and ambient air quality greatly varies according the local activity such as transport and small scale industry. The dispersion of concentration these pollutants PM_{10} & $PM_{2.5}$ is depicted in Figure 12 and Figure 13. The dispersion contours has been

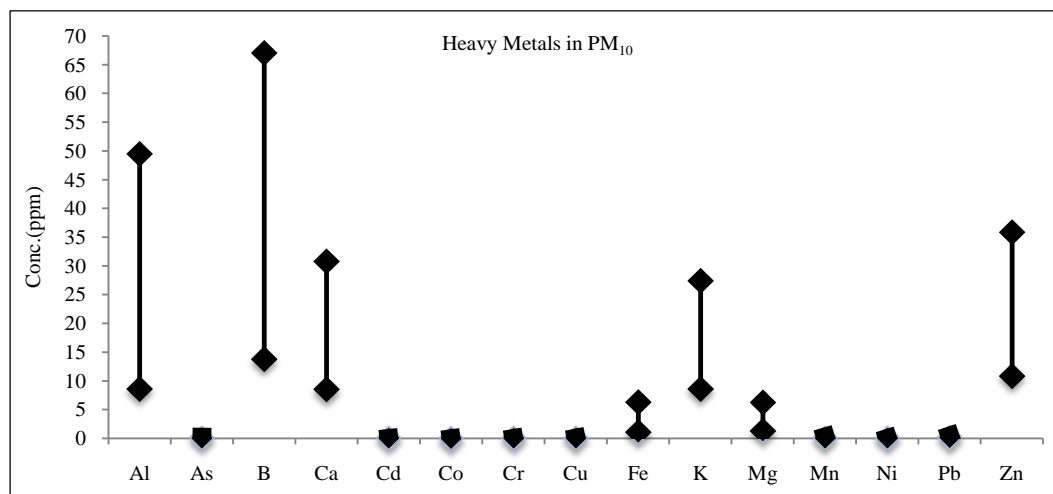


Figure 10. Heavy metal characterizations in PM₁₀ during Diwali festival.

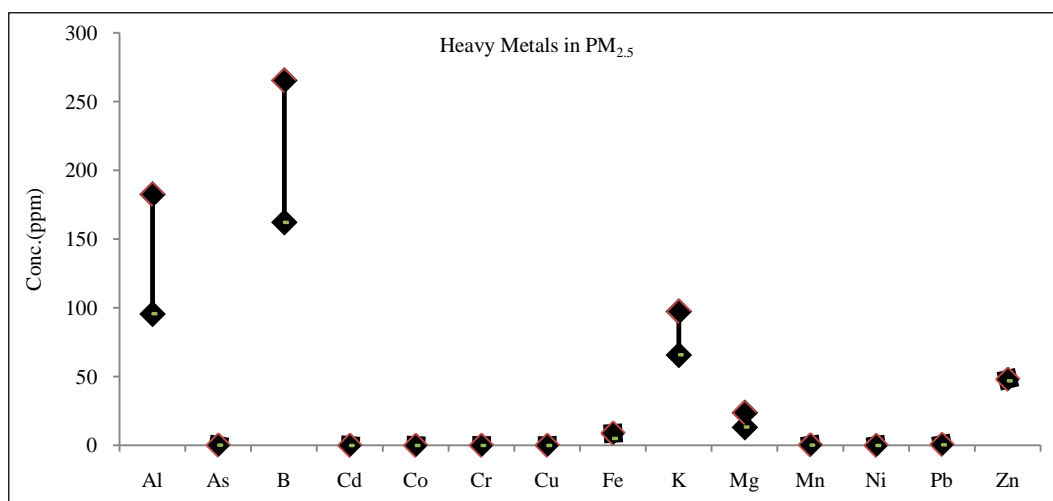


Figure 11. Heavy metal characterizations in PM_{2.5} during Diwali festival.

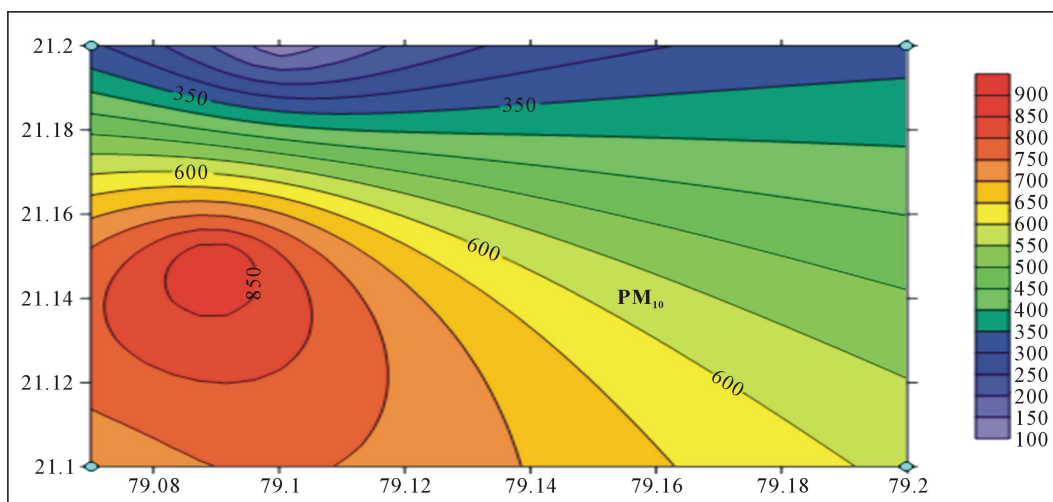


Figure 12. Dispersion of PM₁₀ across the Nagpur city during Diwali days.

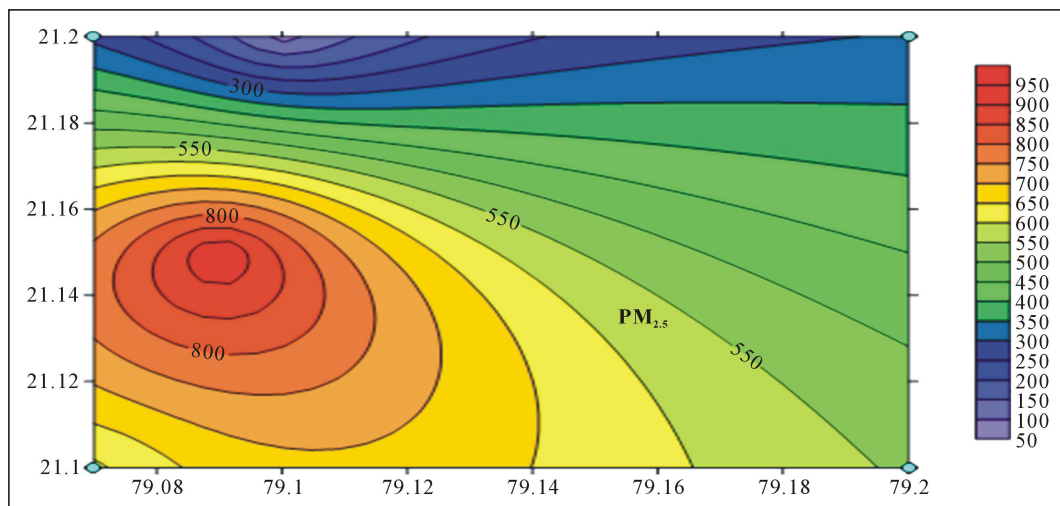


Figure 13. Dispersion of $PM_{2.5}$ across the Nagpur city during Diwali days.

Table 3. Summary of air quality during day times of Diwali days.

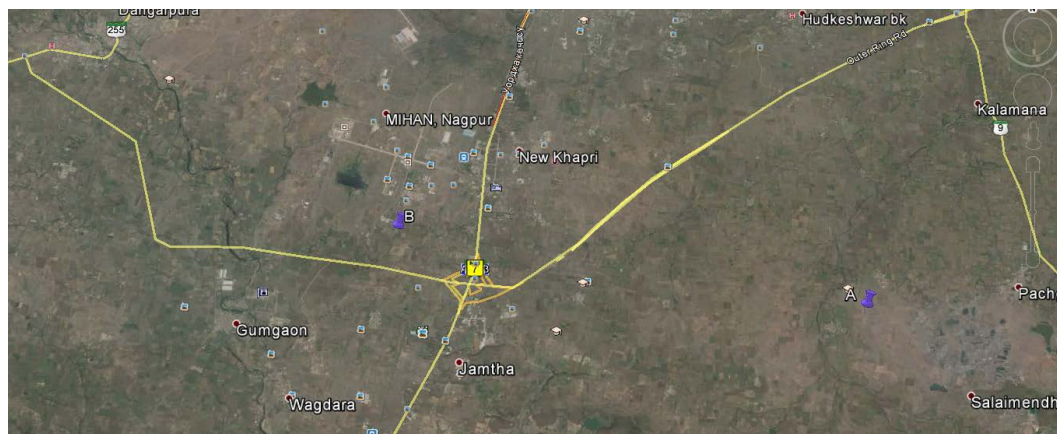
Correlation Coefficient of Pollutant During Day Time				
PM_{10}	Normal Day	Pre Diwali	Diwali	Post Diwali
Normal Day	1			
Pre Diwali	0.80	1		
Diwali	0.60	0.48	1	
Post Diwali	-0.23	-0.39	-0.33	1
$PM_{2.5}$	Normal Day	Pre Diwali	Diwali	Post Diwali
Normal Day	1			
Pre Diwali	0.76	1		
Diwali	0.41	0.55	1	
Post Diwali	0.14	0.51	0.41	1

Table 4. Summary of air quality during night times of Diwali days.

Correlation Coefficient of Pollutant During Night Time				
PM_{10}	Normal Day	Pre Diwali	Diwali	Post Diwali
Normal Day	1			
Pre Diwali	0.49	1		
Diwali	0.62	0.48	1	
Post Diwali	0.51	0.42	0.33	1
$PM_{2.5}$	Normal Day	Pre Diwali	Diwali	Post Diwali
Normal Day	1			
Pre Diwali	0.49	1		
Diwali	0.01	0.57	1	
Post Diwali	0.78	0.41	0.04	1

Table 5. Summaries of PM₁₀ & PM_{2.5} during Diwali days.

Parameters	Correlation	Regression	R ²
During Diwali Days	0.824	PM ₁₀ = 0.97 PM _{2.5} = 0.69	0.68
Day Time (Diwali day)	0.97	PM ₁₀ = 0.85 PM _{2.5} = 1.11	0.94
Day Time (Diwali day)	0.78	PM ₁₀ = 0.69 PM _{2.5} = 0.87	0.6

**Figure 14.** Satellite image of sampling site at Nagpur.

plotted by using surfer. The model has assumed the study area as a centre point and plots contours of dispersion of pollutants.

This shows that approximate 10 km Area of Nagpur from sampling site. This covers the Mihan, Newkhapri, Gumgaon, Jamtha and Wagdara etc. (Figure 14). The people of these localities are more affected by these pollutants.

4. Conclusion

Study of pre Diwali, Diwali, post Diwali has been investigated in residential Area Nagpur. This study has shown the pollution levels in terms of particulate matter which is higher than the normal day and it remains in the atmosphere after the two days of festival. The particulate matter (PM₁₀ & PM_{2.5}) exceeds the CPCB standard. Though this is time of merriment and income generation, this leads to risk of endangering of health of people.

Acknowledgements

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Recommendations

It is advice to the community of society that they should not only look for income generation and amusement during festival but should also consider the damaging effect in the environment in terms of air quality. We should look for an alternative way from which one can enjoy the festival more but not creating any damage to environment. It has been suggested to the people do not use more cracker during Diwali as creating noise and air pollution both. As it is a lighting festival so we should use some lamps and candle for more enlightenment.

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