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MASS CONCENTRATION OF $PM_{2.5}$ DURING DIWALI IN RAIPUR

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ABSTRACT

Diwali is one of the major festivals of light and is celebrated with great enthusiasm in India every year in late October or early November. During the festival days, houses are illuminated with diyas and lights while sky with firecrackers resulting in emission of large amount of air pollutants. The continuous air pollution monitoring was done during Diwali month from 9-25 October 2017 at Collectorate campus, Raipur. The obtained air quality data were compared with the Central Pollution Control Board (CPCB) standards. $PM_{2.5}$ mass concentrations before and after Diwali ranged as 137.17-564.05 μg/m^3, and 79.46-266.26 μg/m^3 respectively and on Diwali as 171.20-517.67 μg/m^3 ,which remained in atmosphere for two days causing adverse impact on human cardiovascular and respiratory systems. The average concentration of $PM_{2.5}$ during Diwali month was recorded as 227.71μg/m^3 while average temperature and relative humidity were found to be 29ºC and 68% respectively. Thus, the use of firecrackers needs to be controlled to ensure good air quality for better public health.

Keywords: Particulate matter, Diwali, firecrackers, air pollution, public health

INTRODUCTION

Diwali, festival of lights, is one of the most important and biggest festivals of Hindu community and is widely and enormously celebrated across India. According to Gregorian calendar, Diwali festival usually occurs in late October or early November and is celebrated for three days all over India. Huge amount of fireworks, crackers and sparklers are burnt mainly during the festival days resulting in emission of large quantities of various gases including ozone, oxides of sulphur, nitrogen and carbon, toxic elements, volatile organic compounds, polycyclic aromatic hydrocarbons, particulate matter (PM) etc in significant quantity in ambient air thus degrades the air quality as a whole.

PM released during burning of crackers, plays an important role in the atmosphere because of various gases and other chemicals adsorbed by these particles, thus imparts adverse effect on regional visibility, climate change and has a disproportionately harmful impact on human cardiovascular and respiratory systems. The toxic levels of PM has been influenced by various physical properties (particle size and mass) as well as chemical properties like chemical composition including organic and elemental carbon, sulphate and nitrate salts, elements and ions etc. of PM. Size is measured in aerodynamic diameter and is a very determinable property for deposition of these different size particles in different parts of respiratory system. In India, Central Pollution Control Board (CPCB) has laid down daily National Ambient Air Quality Standards (NAAQS) for PM_{10} and $PM_{2.5}$ as 100 μg/m^3 and 60 μg/m^3 respectively.

The urban air quality differs from one region to another not only on the basis of different localities but also on the type of activities going in the area including industrial, construction, transportation etc. In the present study, an urban site in Raipur has been selected for monitoring $PM_{2.5}$ aerosol mass concentration to observe the effect of cracker burning during celebration of Diwali festival.

MATERIALS AND METHODS

Study Area

Raipur District (latitude: 21° 132 N, longitude: 81° 372 E, altitude: ~290 m above sea level) is situated in the fertile plains of Chhattisgarh Region (Figure 1). Raipur city, the capital of Chhattisgarh, is known as business centre place of surrounding cities and adjoining states, e.g. Orissa in East, Madhya Pradesh in North, Maharashtra in West and Andhra Pradesh in South. As per 2011 census, the Raipur urban agglomeration has a population of about one million. It is one of the leading industrial and commercial cities of central India. Coal based thermal power plants, steel and sponge iron industries, agriculture based industries such as rice mills, and other metal based industries, cement industries etc are the main industries in Raipur district. It has a tropical wet and dry climate; temperatures remain moderate whole of the year, except from March to June, which can be extremely hot. The highest temperatures were observed

during the months of April-June (summer) whereas the lowest temperatures were observed during the months of November-January (winter). The city receives about 1,300 millimetres of rain, mostly in the monsoon season from late June to early

Fig.1. Representation of the monitoring location (Collectorate Campus)

October. Because of local industrial and human activities and regional transport, air quality of the city is a major concern. Particulate matter (PM) is a governing factor of air quality index.

Instrumentation and Sampling Techniques

In order to determine the influence of bursting of fireworks during Diwali festival on air quality, the real time monitoring of particulate matter was undertaken from 9/10/2017 to 25/10/2017 at Collectorate (traffic interaction zone) Raipur. In the present study ambient air quality was measured by CAAQMS (Continuous Ambient Air Quality Monitoring Station) which works on the principle of Beta Attenuation Method (BAM, Thermo Fisher Scientific) for measuring and analysis of $PM_{2.5}$ mass concentration. Each hour, a small C^{14} (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. Simultaneously, sampling of aerosol was carried out using high volume sampler for $PM_{2.5}$ mass

concentration measurement. The duration of sampling was approximately 24 hours at a constant flow rate of 1130 L/min. Aerosol samples were collected on Whatman glass fiber filter of size 8" × 10". For conditioning, the filter papers were placed in dessicators for 24 hours before and after sampling and weighed using a microbalance (MAB series 220). The concentration of aerosol was determined gravimetrically by dividing the difference in weight on the filter paper before and after sampling with the volume of air sampled. In this paper we report only $PM_{2.5}$ mass concentration measured from high-volume sampler gravimetrically.

Meteorological data

The meteorological parameters like relative humidity, air temperature, etc. at the study region were collected from Indira Gandhi Agriculture University, Raipur in order to identify the effect of local meteorology on pollution levels.

RESULTS AND DISCUSSION

The study of the urban air quality near the traffic interaction site of Raipur city during Diwali periods was designed to compare the air quality during that period and to determine whether the particulate matter concentration was within the recommended NAAQS standards or not. Diwali is one of the biggest festivals of India dominated with the most extensive burning of fireworks causing major environmental problems and other harmful impacts on human cardiovascular and respiratory systems. The monitoring of particulate matter during peak hours was done and the average concentrations of $PM_{2.5}$ in the ambient air are given in the Table 1.

Table1. Ambient particulate matter mass concentration during the study period

Day	Date	Air Quality Parameter	Air Quality Standards CPCB (NAAQS 2009)	
		$PM_{2.5}$ ($\mu g/m^3$)	Annual	Daily (24hr.)
Before Diwali	09/10/2017	205.46		
	10/10/2017	150.83		
	11/10/2017	350.61		
	12/10/2017	209.09		
	13/10/2017	159.51		
	14/10/2017	170.85		
	15/10/2017	146.62		
	16/10/2017	286.39	40	60
Dhanteras	17/10/2017	299.26		
Choti Diwali	18/10/2017	397.71		
Diwali	19/10/2017	253.26		
Goverdhan Pooja	20/10/2017	344.435		
After Diwali	21/10/2017	232.11		
	22/10/2017	93.71		
	23/10/2017	116.76		
	24/10/2017	89.08		
	25/10/2017	266.26		

$PM_{2.5}$ mass concentrations ranged as 137.17-564.05 $\mu g/m^3$ before Diwali, 171.20-517.67 $\mu g/m^3$ on Diwali and 79.46-266.26 $\mu g/m^3$ after Diwali (Fig. 2).

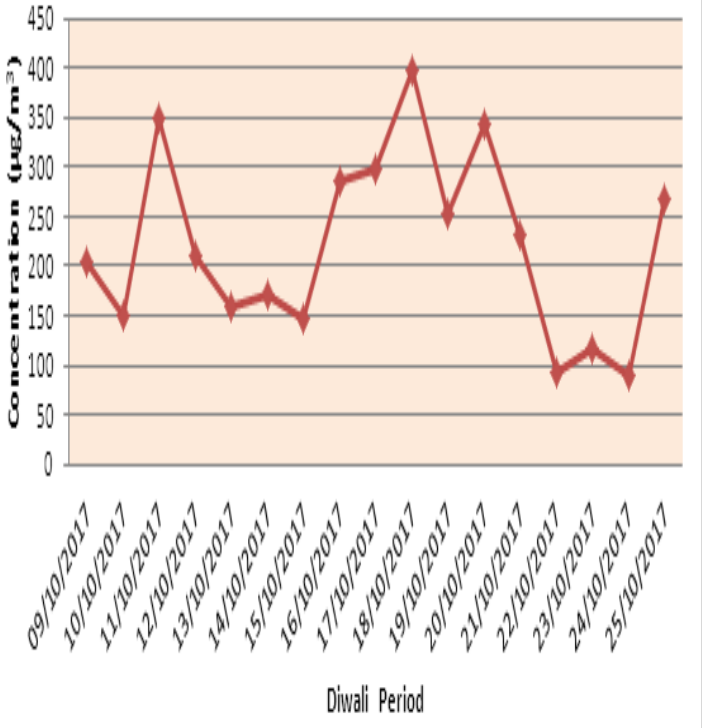

Fig.2. Variation in $PM_{2.5}$ mass concentration before Diwali, on Diwali and after Diwali

In the present study, it was also found that the concentration of $PM_{2.5}$ was 2-4 times higher than the 24 hours NAAQS of $PM_{2.5}$ before and after Diwali days while almost 5-7times higher than the NAAQS on Diwali day (Fig. 3).

The average concentration of $PM_{2.5}$ during Diwali month was

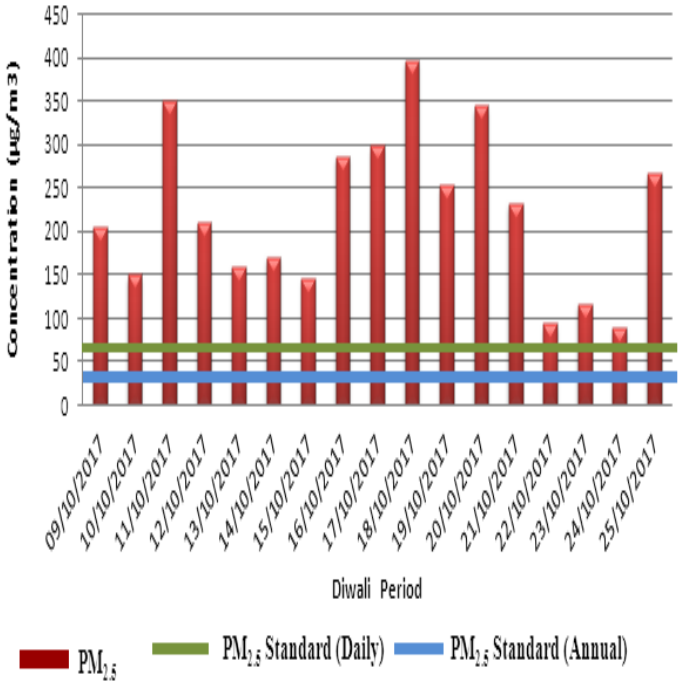

Fig.3. Particulate mass levels with NAAQS standards

recorded as 227.71 $\mu g/m^3$. Also the average temperature and relative humidity during that month were found to be 29ºC and 68% respectively (Table 2).

Table2. High and Low weather conditions during Diwali month

Condition	Temp. (ºC)	Relative Humidity (%)	Pressure (mbar)
High	35	96	1016
Low	23	29	1002
Average	29	68	1007

Meteorological parameters play a very important role in affecting the levels of the pollutants. The meteorology of Diwali month had a significant impact on the pollutant levels and also on urban ambient air quality. In the present study, the relative humidity and temperature varied from 29-96% and 23-35ºC respectively, resulting in the accumulation of pollutants and smog formation which is the main cause of high concentration of particulate matter during Diwali days. Temperature inversion is the poorest meteorological situation in ambient air resulting in less dispersion of pollutants hence increased the level of pollutants by several times. Various

studies on ambient air quality during Diwali in different parts of country revealed that pollutant levels have increased by 2-10 times due to extensive bursting of fireworks.

The $PM_{2.5}$ levels just two days before Diwali i.e. Dhanteras was found to be comparatively higher due to traffic emission and vehicular density on road on account shopping practices leading to more ambient air pollution. As well as one day after Diwali i.e. Goverdhan pooja particulate mass concentration was higher due to accumulation of these particles in the atmosphere.

CONCLUSION

The study concluded that Diwali celebration results in higher PM concentration, particularly before and after Diwali due to increased traffic emission due to higher vehicular density on the road. On Diwali day, despite of low vehicular density in the evening, the bursting of firecrackers results in high PM concentrations leading to more accumulation of particles in atmosphere thus causes adverse impact on human health. Hence the use of firecrackers needs to be controlled to ensure good public health and to improve the air quality.

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