

Episodic Levels of PM₁₀, PM_{2.5} and PM₁ during Diwali: A study in urban area of Delhi, India

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Abstract

Diwali festival is celebrated every year during the time of October-November all across India. During the festival days, firecrackers are burnt in large amount and results in high emission of air pollutants. This year the Supreme Court of India has banned over the selling of crackers during Diwali month in Delhi. Shahdara, an urban area, Delhi has been selected for observing the effect of pollution after banning of the crackers. The monitoring of particulate matter for peak hours has been done six days before, six days after and on Diwali days by using aerosol spectrometer (Grimm 1.108). The Pre-Diwali levels of PM₁₀, PM_{2.5} and PM₁ has been ranged as 614-1307, 246-375 and 195-266 µg/m³ respectively while the Post-Diwali levels of PM₁₀, PM_{2.5} and PM₁ has been ranged from 861-1101, 295-453 and 211-364 µg/m³ respectively. The levels of PM₁₀, PM_{2.5} and PM₁ on Diwali has been found to be 1484, 580 and 447 µg/m³ respectively. Despite cracker ban, the presence of such higher concentration of particulate matter in ambient air during Diwali needs immediate actions for better implementation of policies to ensure healthier public health.

Keywords: Diwali, particulate matter, firecrackers, air pollution, Delhi, Public Health.

Introduction

Diwali, an important occasion of lights and fireworks, celebrated every year during the time of October-- November all across India. During the festival days, large quantities of firecrackers are burnt in ambient air results into emission 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 and degrades the air quality as a whole¹⁻³. It has been found that last year, a huge amount of crackers were burst in Delhi for several days during Diwali resulted in high concentration of pollutants along with toxic smog and due to which government take actions for closing of schools, power stations and various construction activities. This sudden increase in airborne pollution levels last year, led the supreme court of India to ban the sale of fireworks in Delhi during this festival month (October, 2017), in order to avoid increase in the levels of toxic air pollutants.

PM released during burning of crackers, play an important role in the atmosphere because of various elements and ions adsorbed by these particles. The toxic levels of PM has been influenced by various physical and chemical properties, among which physical properties include particle size and particle mass whereas chemical properties include chemical composition including organic and elemental carbon, sulfate and nitrate salts, elements and ions etc of PM⁴. The size of PM is measured in aerodynamic diameter and is a very determinable property for deposition of these different size particles in different parts of

respiratory system. PM₁₀, PM_{2.5} and PM₁ are particulate matter of aerodynamic diameter of 10, 2.5, and 1 µm respectively⁵. It has been cleared from various studies that PM₁₀ and PM_{2.5} are those particle which affect respiratory system, while fine PM_{2.5}, finer PM₁ and ultrafine particles generally not only affect the respiratory system but cardiovascular system also^{3,6,7}. In India, Central Pollution Control Board (CPCB) has laid down 24 hours National Ambient Air Quality Standards (NAAQS) for PM₁₀ and PM_{2.5} as 100 and 60 µg/m³ respectively, while there is no standard for finer particles PM₁, which have more harmful respiratory and cardiovascular effects on health⁸. Various studies carried by Central and State Pollution Control Boards at different urban locations of India have accomplished the short-term degradation in air quality of episodic nature during Diwali⁹.

The urban air quality mostly varies from one region to another, different localities and also on the type of activities in the area including industrial, construction and transportation activities etc¹⁰. In this study, an urban site in Shahdara, Delhi has been selected, which is surrounded by road side and residential area. Hence, simultaneously we can check the effects of cracker burning and traffic congestion on PM levels during these days.

Materials and methods

Study area: Shahdara, a sub-urban region in the Eastern Delhi, India, which is situated near the banks of Yamuna River has been selected for the study. It is located at 28.6988°N and 77.2926°E in globe. Jyoti Colony, an area near Loni road

situated in Shahdara has been selected for the monitoring in this study. The monitoring has been done near roadside at Jyoti Colony area which is surrounded by an old, large temple "Shree Durga Mandir" and also by Makki mosque. The monitoring location is surrounded by various coaching institutes, timber market, hospitals, residential areas and is represented in Figure-1. As per Census 2011, Shahdara has total population of 322,931 out of which 169,409 are males while 153,522 are females¹¹.

25/10/2017). The levels of PM₁, PM_{2.5} and PM₁₀ were measured for four hours (19:00-23:00hours) daily by using aerosol spectrometer (Grimm technology Model 1.108, Germany). The distribution of particle size and mass has been and the working principle of the instrument is orthogonal scattering of light¹². The sampling rate of the dust monitor is 1.2liters/min. The PTFE-Teflon filter paper having a diameter of 47mm and pore size of 0.2micron was used for PM sampling. The results obtained were analyzed by GRIMM software program.

PM Measurements: In order to identify the impact of burning of firecrackers after banning during Diwali festival on air quality the monitoring of particulate matter has been carried out six days before Diwali (13/10/2017-18/10/2017), on Diwali (19/10/2017) and six days after Diwali (20/10/2017-

Meteorological Data: The meteorological parameters like humidity and wind speed at the study region were collected from the CAAQMS (Continuous Ambient Air Quality Monitoring Station), CPCB, in order to identify the effect of local meteorology on pollution levels.

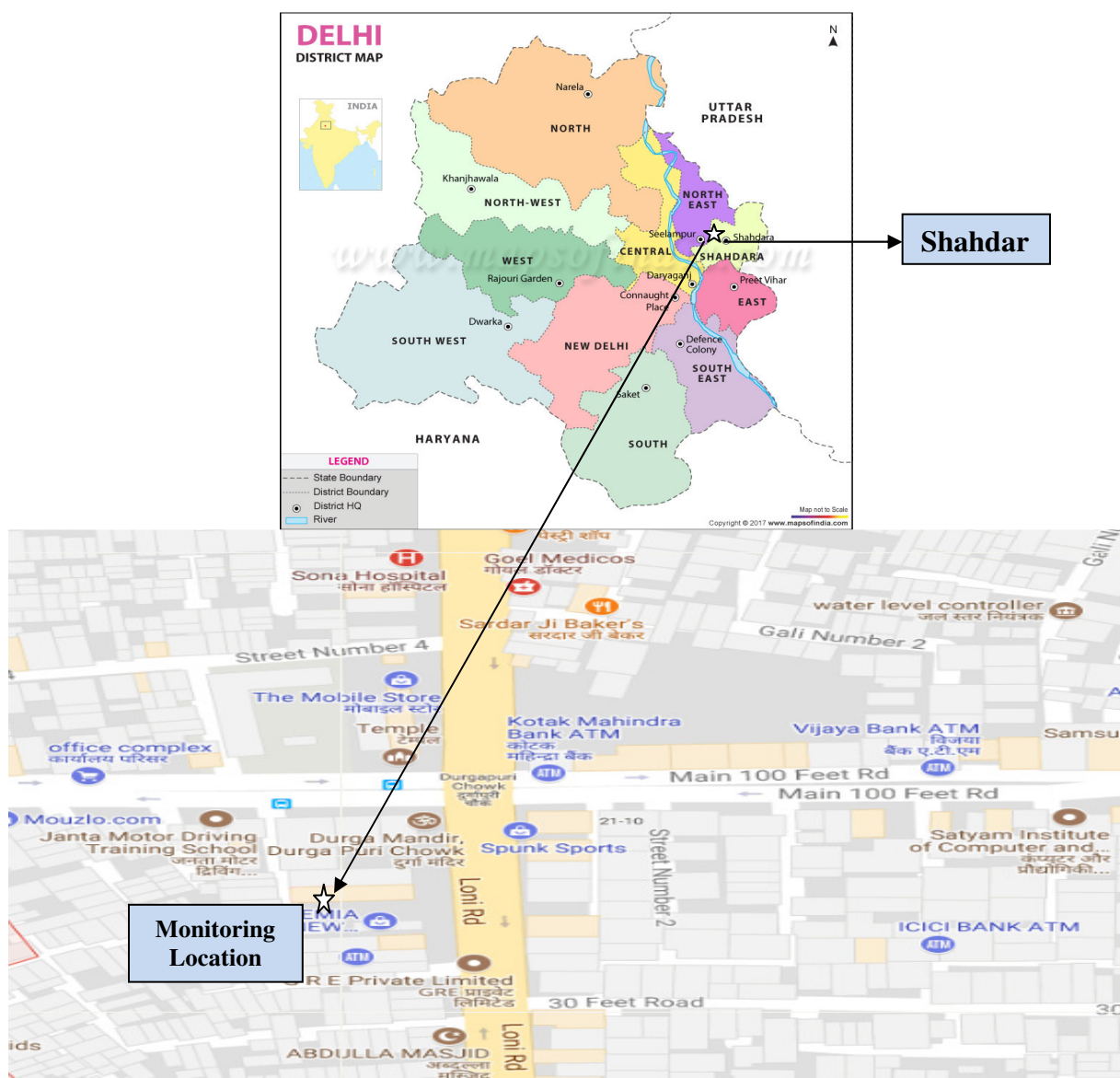


Figure-1: Representation of the monitoring location.

Results and discussion

The study of urban air quality near roadside location of Shahdara, Delhi during Diwali, pre and post Diwali periods was designed to compare the urban air quality during that period and to identify whether the concentration of PM is within NAAQS standards or not. Since, this year the Supreme Court of India has banned over the selling of crackers during Diwali month in Delhi hence monitoring has been done for observing the effect of pollution after banning of the crackers. The monitoring of particulate matter during peak hours has been done and the average concentration of PM₁₀, PM_{2.5}, PM₁, relative humidity and wind speed has been given in Table-1.

From Figure-2, it has been found that the Pre-Diwali levels of PM₁₀, PM_{2.5} and PM₁ has been ranged as 614-1307, 246-375 and 195-266µg/m³ respectively, the Post-Diwali as 861-1101, 295-453 and 211-364µg/m³ respectively and on Diwali as 1484, 580 and 447µg/m³ respectively. In this study, it was also observed that PM₁₀ levels were 7-12 times higher than 24 hrs NAAQS of PM₁₀ during pre- and post Diwali days, while almost 15 times higher on Diwali. Also, the concentration of PM_{2.5} was 4-6 times higher than 24 hours NAAQS of PM_{2.5} during pre- and post Diwali days, while almost 9 times higher than NAAQS on Diwali (Figure-3). Although, there is no standard norms for PM₁ but these particles reach to alveoli and are associated with very serious health risks and the concentration of these particles on

Diwali was found very high (580µg/m³) which is a serious matter of concern.

The average concentration of PM₁₀, PM_{2.5} and PM₁ during Diwali month was recorded as 1002±230, 352±93 and 263±79 µg/m³ respectively. Also the relative humidity and wind speed during that month was found as 53±8% and 0.70±0.02m/sec.

Meteorological parameters found to play a significant role in affecting levels of the pollutants. The meteorology of October-November months were found to be calm which may have significant impact on the levels of pollutant and also on urban ambient air. In this study, the relative humidity and wind speed during these days varies from 35-64% and 0.64-0.71m/s. Wind speed during Diwali, 2017 was found to be very low (0.64 m/sec) and relative humidity (63%) (Table-1) was relatively high, which leads to the accumulation of pollutant and formation of smog which is the main reason behind why the concentration of fine particles were found comparatively higher on the day after Diwali. Inversion, one of the poorest meteorological situation in ambient air results in the less dispersion of pollutants and hence the levels of pollutants may increased by several times¹³. Various studies conducted in ambient air of different parts of India during Diwali showed that the levels of pollutant increased by 2-10 times during Diwali period due to extensive burning of firecrackers^{2,14-18}.

Table-1: Levels of PM₁₀, PM_{2.5}, PM₁, Relative Humidity and Wind Speed

Day	Date	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	PM ₁ (µg/m ³)	Relative Humidity (%)	Wind Speed (m/s)
Pre-Diwali	13/10/2017	614	263	195	59	0.71
	14/10/2017	766	316	247	53	0.70
	15/10/2017	768	246	179	43	0.71
	16/10/2017	1130	375	266	35	0.71
Dhanteras	17/10/2017	1307	335	233	50	0.69
Choti Diwali	18/10/2017	1002	286	208	57	0.71
Diwali	19/10/2017	1484	580	447	63	0.64
Goverdhan Puja	20/10/2017	1101	451	355	61	0.71
Post-Diwali	21/10/2017	965	453	364	50	0.70
	22/10/2017	861	335	254	48	0.67
	23/10/2017	1041	295	208	57	0.69
	24/10/2017	968	347	258	64	0.71
	25/10/2017	1020	298	211	63	0.71
Average		1002±230	352±93	263±79	53±8	0.70±0.02

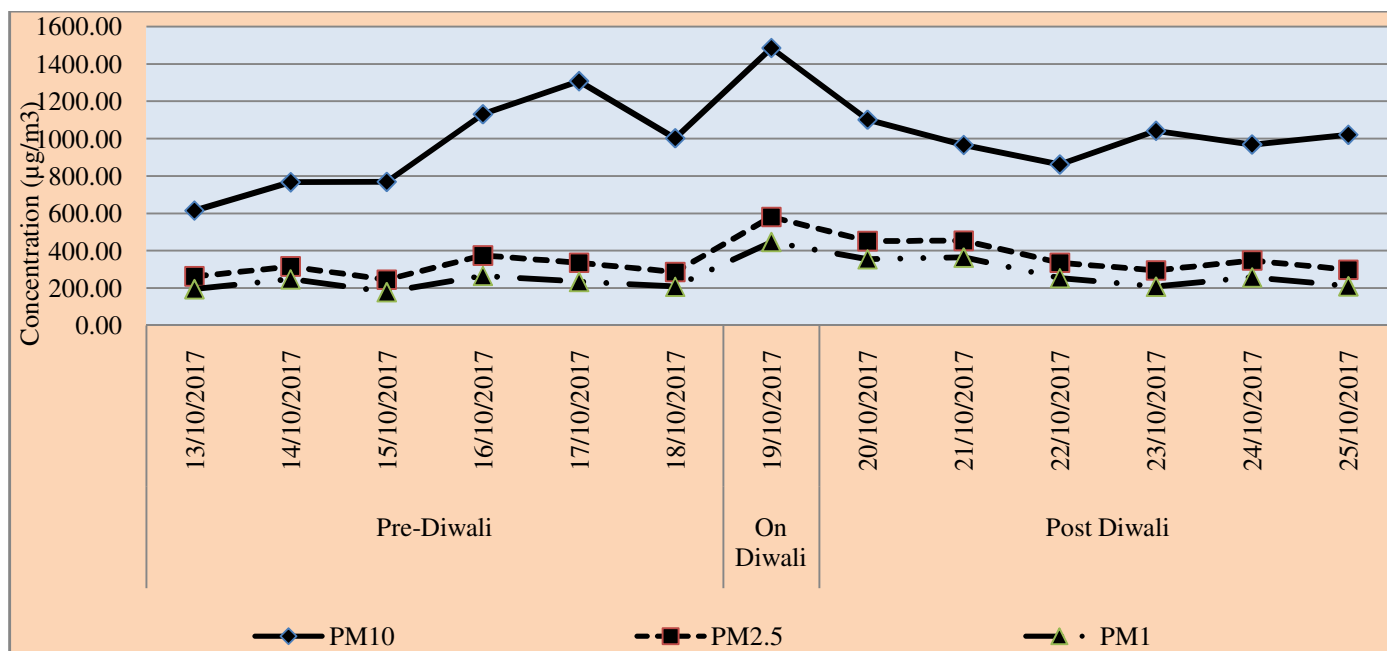


Figure-2: Variation in PM during Pre- Diwali, On Diwali and Post- Diwali events.

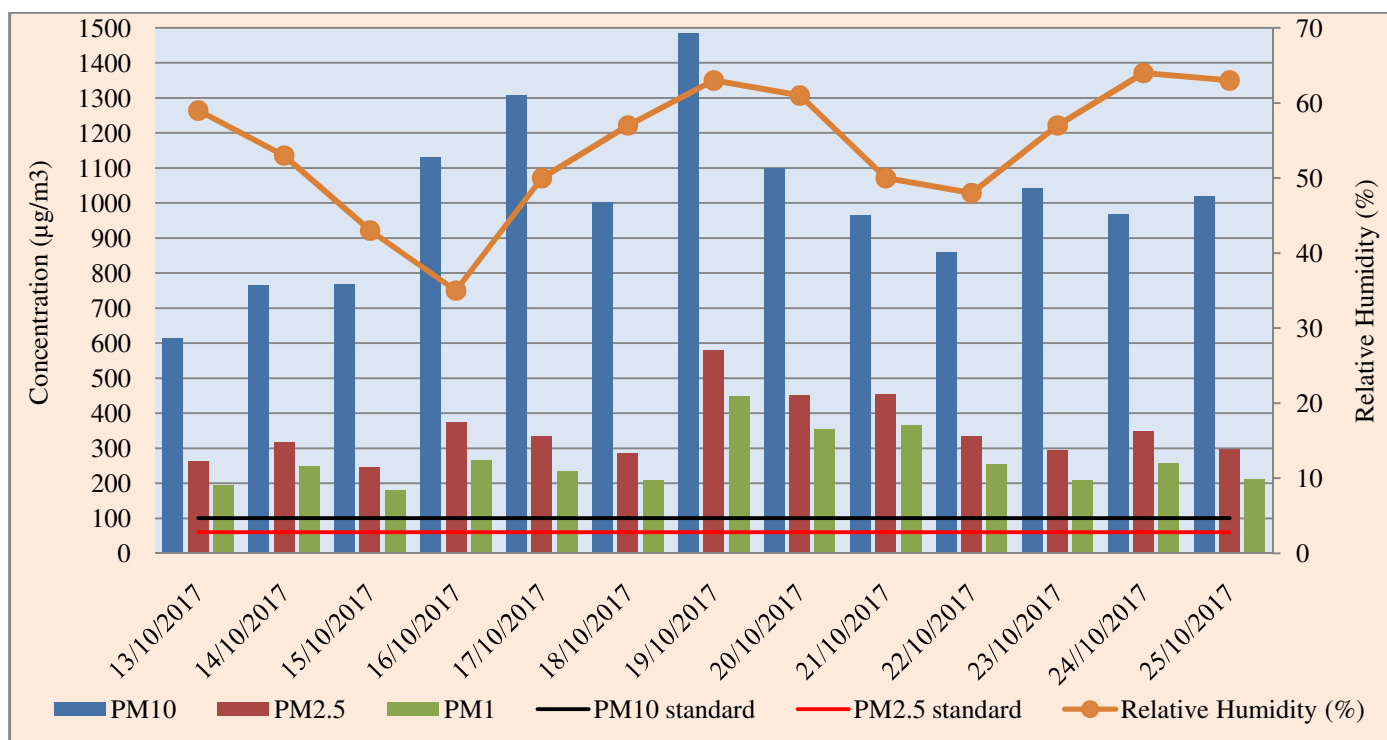


Figure-3: PM level with NAAQS standards and Relative Humidity.

The levels of PM₁₀, PM_{2.5} and PM₁ (1307, 335 and 233µg/m³ respectively) on two days before Diwali i.e. Dhanteras were found to be higher indicating that due to shopping practices the vehicular density and traffic congestion on road was increased and results in more ambient pollution. While the levels of PM₁₀, PM_{2.5} and PM₁ (1101, 451 and 355µg/m³ respectively) on one day after Diwali i.e. Goverdhan Puja were comparatively

higher. After post Diwali fine particle concentrations were observed comparatively higher because of accumulation of these particles in the atmosphere. From Figure-4, it was observed that very strong positive correlation has been found between PM_{2.5} and PM₁ indicating the same emission source and because both particles are fine and hence accumulate for long time in comparison with PM₁₀.

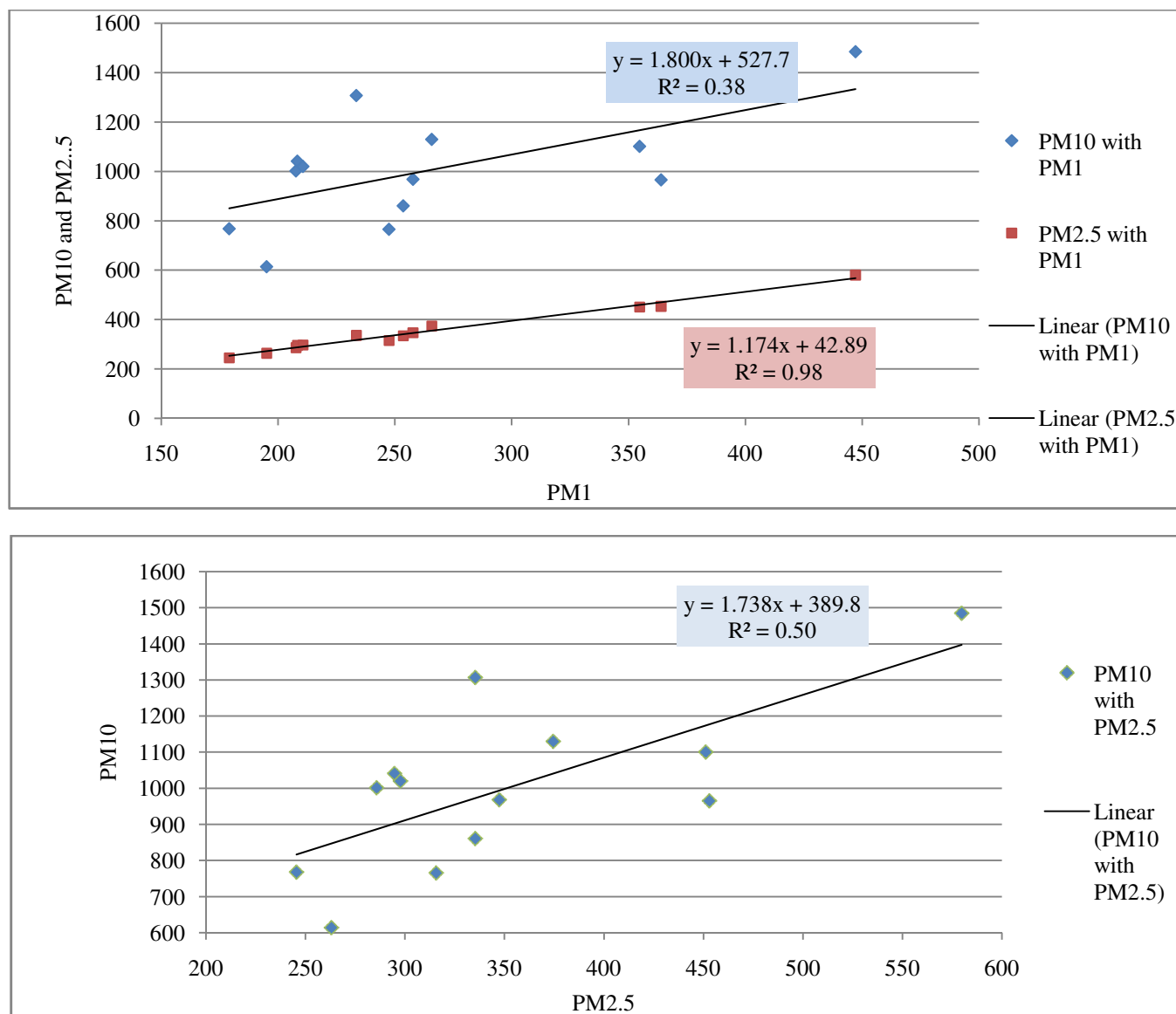


Figure-4: Scatter plots for different Particle size with R-squared value.

Conclusion

This study concluded that the celebrations of Diwali were result in higher concentration of PM. The concentrations of PM were found to be comparatively higher during Dhanteras day indicating that due to shopping practices the vehicular density and traffic congestion on road at that day was higher and on Diwali day, although the vehicular density is less in evening but burning of fireworks results in higher concentration of PM. The day after Diwali, the concentration of fine particles i.e. $PM_{2.5}$ and PM_1 were found to be comparatively higher because of more accumulation of these particles in the urban atmosphere. Although the festival like Diwali is the time when all the businessmen got maximum profit to their companies by selling their products including crackers but providing good quality of air is also very necessary for the health of people. Hence, this

study has been found to be helpful in order to identify the impact of Diwali celebrations in urban area. Despite cracker ban, the presence of such higher concentration of particulate matter in ambient air during Diwali needs immediate actions for better implementation of policies to ensure healthier public health.

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