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Full Length Research Paper

Measurement of Particulate Pollution in Jabalpur City during Diwali Festival

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Abstract

The ambient air quality monitoring network involves measurement of a number of air pollutants. A variety of methods exist to measure particulate matter in air. This study evaluates the effects of particulate air pollution associated short-term exposure of particulate matter (PM_{10} and $PM_{2.5}$) in Diwali festival. Fireworks display during festive celebrations can cause acute short term air pollution. Concentration of air pollutants such as PM_{10} and $PM_{2.5}$ was monitored for six consecutive days during Diwali in, a densely populated residential area near, Jabalpur, India for assessing the impacts of fireworks on ambient air quality. The study was conducted for two consecutive years i.e. 2012 and 2013. The result shows that air quality deteriorates during Diwali festival is due to the use of excessive amount of firecrackers. A comparative account of two years air quality data is also presented.

Keyword: Particulate Matter (PM_{10}, $PM_{2.5}$), Air Quality, Meteorological Parameter, firework comparison of air quality, Diwali festival, ozone.

INTRODUCTION

In general, PM (Particulate matter) is a complex mixture of elemental and organic carbon, ammonium, nitrates, sulphates. Fine particles which are very small in size generally have long residence time in the atmosphere and tend to spread over a large geographic region and thus exert the greatest effect on vegetation and ecosystems by virtue of the mass loading of its chemical constituents and vegetation. This effect can be seen in industrial and highly polluted area like metropolis city. Singh et al., (2009) studied the temporal variation in ambient air quality during Diwali festival in India. For pre-Diwali, Diwali festival, post-Diwali, and foggy day, the variation in air quality was assessed from the ambient concentrations of various air pollutants as total suspended particle (TSP), particulate matter ≤10µm (PM10).They found the concentrations of PM_{10} increased two to six times during the Diwali period and the levels of pollutants observed during Diwali were found to be higher due to adverse meteorological conditions, i.e., decrease in 24 h average mixing height, temperature, and wind speed. The trend analysis shows that TSP and PM_{10} concentration increased just before Diwali and reached to a maximum concentration on the day of the festival. The values gradually decreased after the festival. These results indicate that fireworks during the Diwali festival affected the ambient air quality adversely due to emission and accumulation of TSP, PM_{10}.

Barman et al., (2009) analyzed fine particles ($PM_{2.5}$) in ambient air of Lucknow city due to fireworks on Diwali festival. The 24 hr mean $PM_{2.5}$ of normal day, pre Diwali day, Diwali day and post Diwali day was found higher pollution and the 12 hr mean concentration of $PM_{2.5}$ on

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Diwali night was significantly higher than normal day and pre and post Diwali night. Thakur et al., (2010) studied Air pollution from fireworks during festival of lights (Diwali) in Howrah, India - a case study. They monitored concentration of SPM, PM_{10} and $PM_{2.5}$ during Diwali in Salkia near Kolkata, India for assessing the impacts of fireworks on ambient air quality. The pollutant concentrations as recorded on Diwali were found to be several times higher as compared to a typical winter day value. The results indicated the huge contribution of fireworks on the pollutant levels. Concentrations of metals like Ba, Cu, Cd, Pb, Hg, Al in collected samples of $PM_{2.5}$ were found to be increased by many times on Diwali as compared to the previous day. Vyas and Saraswat (2012) studied the Atmospheric aerosol's parameters during pre-Diwali to post–Diwali festival period over Indian semi arid station i.e., Udaipur. In this paper, they described the day to day changes in atmospheric aerosol's parameters namely AI300, AOD550, β TWC, β and MC value over Udaipur during period from 2002 to 2007. Daily variations in such aerosol's parameters values from pre-Diwali to post Diwali period show the substantial increase of the order of 30- 60%. The main possible cause may be due to increase in aerosol's loadings of inter mixed effect of local emission activity and long range transport of aerosols from heavy polluted IGP site and in reduction of PBL height and wind speed.

The effects of fireworks on air quality was assessed from the ambient concentrations of PM_{10}, water soluble ionic species, metals and SO_2 over Kolkata ,India during Diwali festival which was studied by Chatterjee et al., (2013) on Ambient air quality during Diwali festival over Kolkata – A mega-city in India. They identified the PM_{10} concentrations on Diwali night and found PM_{10} concentrations was higher than the normal day night-time average and water soluble ionic species showed also higher concentrations. The impact of bursting crackers and fireworks on the ambient air quality due to Diwali festival was studied by Khan et al., (2013). They analyzed ambient air quality of Aligarh city (U.P., INDIA) on Diwali day. The SPM concentration estimated at residential site during the day and night times for pre-Diwali, Diwali day and post-Diwali, the level of SPM value was very high as compared with any normal day. Fireworks in large amounts aggravate the level of air pollutants and cause significant short-term air quality degradation with possible impact on human health.

Li et al., (2013) investigated Individual metal-bearing particles in a regional haze caused by firecracker and firework emissions. Intensive firecracker/firework displays during Chinese New Year (CNY) release fine particles and gaseous pollutants into the atmosphere. They monitored ambient $PM_{2.5}$ and black carbon (BC) concentrations. They found that MOUDI images showed that there was a haze event during the CNY. Daily average $PM_{2.5}$ concentration reached six times higher than that before and after the CNY. Similarly, the black carbon (BC) concentrations were elevated during the CNY. They also found that sulfate and organic-rich particles were dominant in the atmosphere before and after the CNY. These data suggest that it was the aerosol particles from the firecracker/firework emissions that induced the regional haze episode during the CNY. Yerramsetti et al., (2013) studied the impact assessment of Diwali fireworks emissions on the air quality of a tropical urban site, Hyderabad, India, during three consecutive years. They focused on the influence of Diwali fireworks emissions on surface ozone (O_3), nitrogen oxides (NOx), and BC aerosol concentration over the tropical urban region of Hyderabad, India during three consecutive years. They found that a twofold to threefold increasing in O_3, NOx, and BC concentrations during the festival period compared to control days. This is mainly attributed to firecrackers burning.

Diab and Hatzopoulou (2013) investigated the Air pollution impacts of major events: A study of the effects of Montreal's largest festivals on downtown air quality. This paper investigated the effects of several outdoor events, including fireworks and car racing competitions, on downtown Montreal's air quality using data spanning several years. They analyze data collected by Montreal's fixed-site air quality monitoring stations using a transformed curves method and regression analysis. They observed that major fireworks have a positive and statistically significant effect on fine particle ($PM_{2.5}$) concentrations in downtown Montreal. Firework induced large increase in trace gases and black carbon at Dibrugarh, India was studied by Pathak et al., (2013) religious, occasional and annual fire work festivals worldwide are found to introduce high concentrations of pollutant gases and particulate matter into the atmosphere. These in turn alters the air quality of a region in the short and long time scales and affect human health adversely during the Diwali festival.

Significance of the Study

The present study has been aimed to assess the air quality during the Diwali festival (a festival in which large quantities of crackers are used) and its comparison with previous years air quality data during the same period. This study provides the useful information about the changes occurred in air quality data in two years of study i.e. 2012 and 2013.

MATERIAL AND METHOD

Site specifications

Jabalpur is a fast developing city of central Madhya Pradesh situated at 23°9′38″N 79°56′19″E. It is heart of the country. The Narmada River is a part of this city. This city has a sub tropical type of climate with May being the hottest and January being the coldest month. The area of the city 367 km^2 (142 sq mi).

Sampling and analytical procedure

The data on air quality monitoring are collected using AQMS.

Ecotech established an instrument for environmental monitoring that is WinAQMS (Air Quality Monitoring Station). WinAQMS has been designed as a client/server program. This means that WinAQMS has two parts: the client and the server. The server handles all the communication between the logger and the analysers, recording of data and starting/stopping of calibrations. The client is concerned with giving the users access to settings and data. On its own the server has no user interface and there is no way you can interact with it using the mouse or keyboard. The client is the visual interface of WinAQMS and communicates with the server by requesting information or receiving information that it has asked for at a prior time. This arrangement means that the WinAQMS server must always be turned on before the WinAQMS client program can connect to it.

Beta Attenuation Monitor (BAM): The Met One instruments model BAM-1020 automatically measures and records particulate concentration levels using the principal of beta ray attenuation. This method provides a simple determination of concentration in units of milligrams or micrograms of particulate per cubic meter of air. A small ^{14}C (carbon 14) element emits a constant source of high-energy electrons known as beta particles.

These beta particles are detected and counted by a sensitive scintillation detector. An external pump pulls a measured amount of dust-laden air through a filter tape. After the filter tape is loaded with ambient dust, it is automatically placed between the source and the detector thereby causing an attenuation of the beta particle signal. The degree of attenuation of the beta particle signal is used to determine the mass concentration of particulate matter on the filter tape, and hence the volumetric concentration of particulate matter in ambient air.

Through this AQMS, the data about $PM_{2.5,}$ PM_{10}, carbon monoxide, ozone and nitrogen oxide are obtained. This instrument can give data of various parameters of desired duration. For the present study, the daily averages of different parameters (as mentioned above) are obtained for the pre-Diwali, Diwali and post-Diwali period. This study was carried out in two different years i.e. 2012 and 2013 to know the changes if any in the air quality.

AWS (Automatic Weather Station):- This instrument provides metrological data e.g. wind speed, pressure, humidity, temperature, wind direction and rain fall with the help of intercept-software. It gives every 10 minutes data.

Observation table 1, daily variation in 2012, figure 1, 2, 3 and table 2.

Daily variation in 2013, figure 4, 5, 6, table 3 and figure 7

RESULTS and DISCUSSION

The data of $PM_{2.5}$ and PM_{10} for the Pre-Diwali, Diwali and Post-Diwali day for the year 2012 and 2013 are presented in Table 1, Table 2, and Figure 1 to 2. The result shows that average $PM_{2.5}$ concentration was around 60µg/m^3 in pre-Diwali days in 2012 which was nearly similar (60µg/m^3) in the year 2013. The average concentration of $PM_{2.5}$ rose to 106µg/m^3 on the Diwali day, the maximum was observed on the next day (average 136µg/m^3) in the year 2012. The average concentration of $PM_{2.5}$ also rose in the year 2013 on Diwali day but as compared to 2012 it was not so high (70µg/m^3) with a maximum average concentration the next day (81µg/m^3).

Similar results are also observed for PM_{10} for both the year. In the year 2012 the average PM_{10} concentration for pre-Diwali days was around 100µg/m^3which rose to average concentration 142µg/m^3 on Diwali Days and increased to average concentration 161µg/m^3 on the next day. In the year 2013 the average concentration of PM_{10} for pre-Diwali days was 100µg/m^3 as in 2012 but in post-Diwali day it rose only to average maximum concentration of 121µg/m^3 as compared to 161µg/m^3 of 2012 and in the following days it receded.

The result shows that the $PM_{2.5}$ and PM_{10} concentration was higher in 2012 on Diwali and post-Diwali days as compared to 2013. The reduction may be attributed to less use of firecrackers. (Table 3, Figure 7)

There is no difference observed in temperature during pre-Diwali, Diwali and post-Diwali time in both the years. (Table-1 and 2)

There is a slight increases in CO concentration during post-Diwali time in the year 2012 (Table 1) and slight increases on the Diwali day in the year 2013 (Table-2) and then decreases in both the year during post-Diwali time.

NO_2 concentration increases on the day of Diwali in both the year (Table 1 and 2) and then decreases in

Table 1. Ambient concentration of particulate and gaseous pollutants compare with meteorological parameter (temp.) in the college campus recorded Pre-Diwali, Diwali and Post-Diwali 2012.

Day	Year	Particulate Pollutants (µg/m^3) Daily avg.		Meteorological Parameter	Gaseous Pollutants		
	2012	$PM_{2.5}$	PM_{10}	Temp. (°C)	CO (ppm)	O_3 (ppb)	NO_2 (ppb)
Pre-Diwali	10.11.12	63	109	21	0.27	55	19
	11.11.12	63	105	22	0.33	58	17
	12.11.12	60	103	23	0.38	58	30
Diwali	**13.11.12**	**106**	**142**	**23**	**0.47**	**59**	**32**
Post-Diwali	14.11.12	136	161	22	0.67	57	47
	15.11.12	82	97	20	0.20	55	14
	16.11.12	75	112	20	0.23	67	10

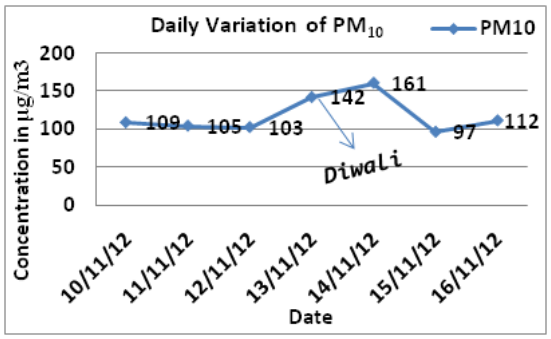


Figure 1. Daily variation PM2.5 (2012)

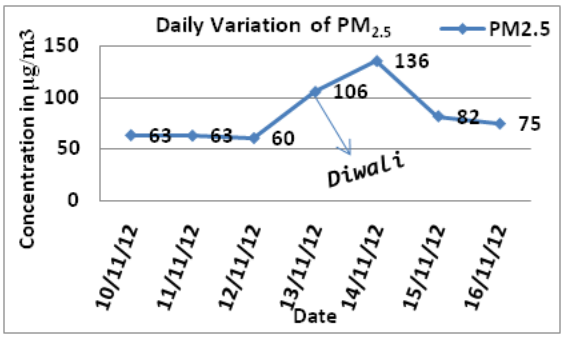
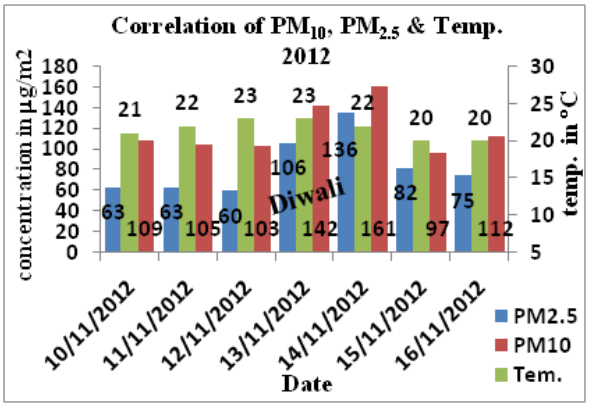
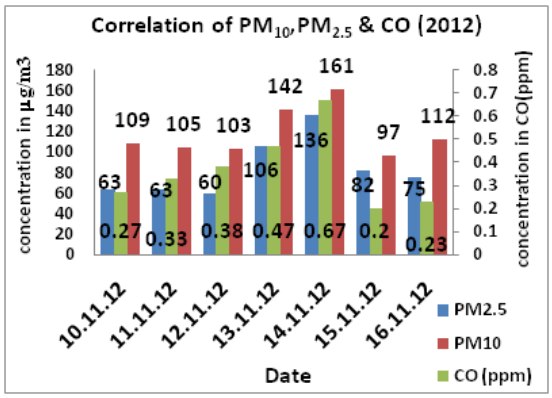
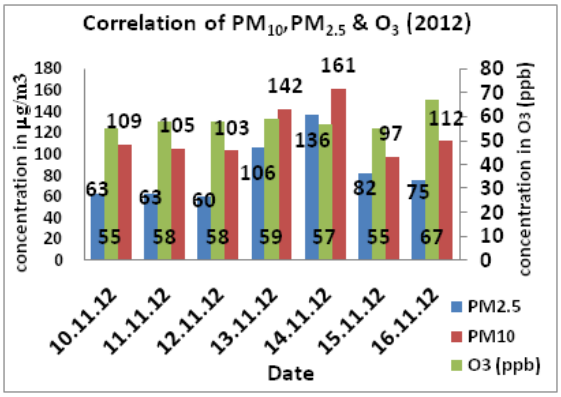


Figure 2. Daily variation of PM10 (2012)







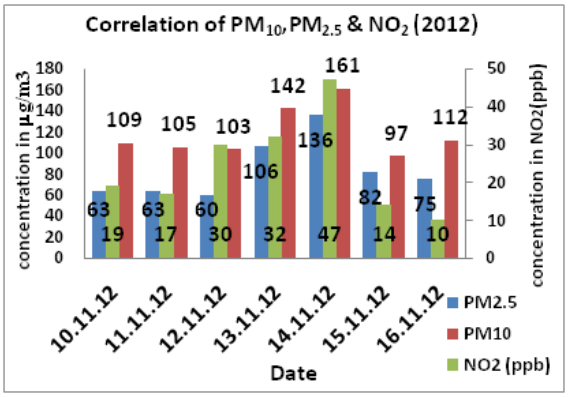


Figure 3. Comparison of PM_{10} and $PM_{2.5}$ with Tem., CO, O_3 & NO_2 (2012)

Table 2. Ambient concentration of particulate and gaseous pollutants compare with meteorological parameter (temp.) in the college campus recorded Pre-Diwali, Diwali and Post-Diwali 2013.

Day	Year	Particulate Pollutants ($\mu g/m^3$) Daily avg.		Meteorological Parameter	Gaseous Pollutants		
	2013	$PM_{2.5}$	PM_{10}	Temp. (°C)	CO (ppm)	O_3 (ppb)	NO_2 (ppb)
Pre-Diwali	31.10.13	53	103	25	0.24	44	11
	01.11.13	55	92	24	0.10	60	15
	02.11.13	61	101	25	0.11	60	14
Diwali	**03.11.13**	**70**	**113**	**25**	**0.15**	**53**	**15**
Post-Diwali	04.11.13	81	121	24	0.14	50	21
	05.11.13	68	100	22	0.13	48	18
	06.11.13	51	82	22	0.14	54	14

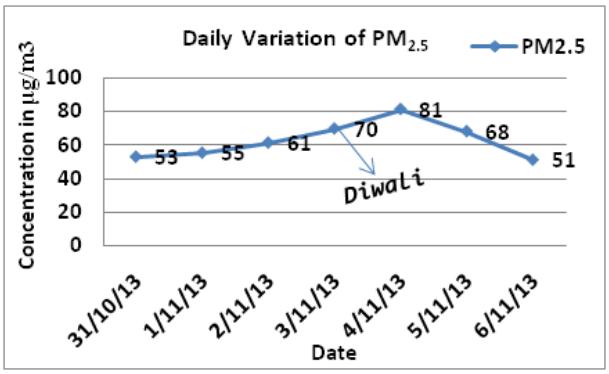


Figure 4. Daily variation of PM2.5 (2013)

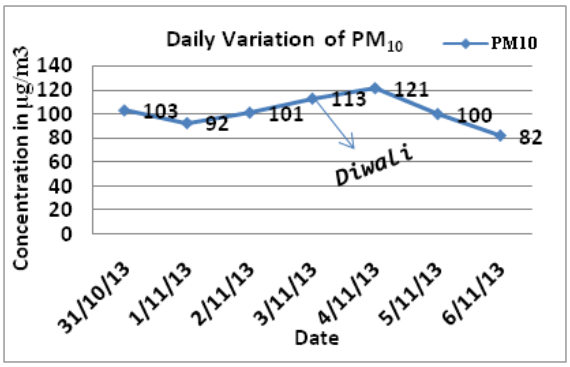
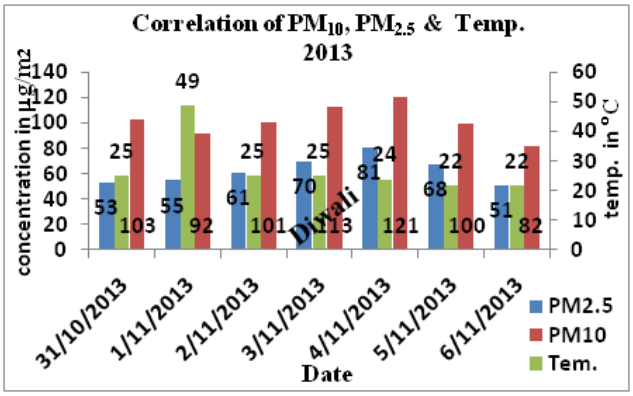
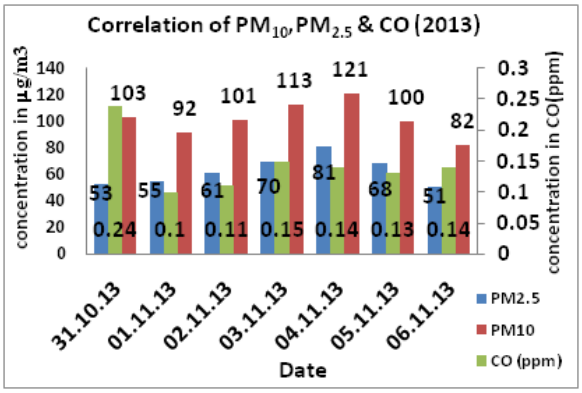
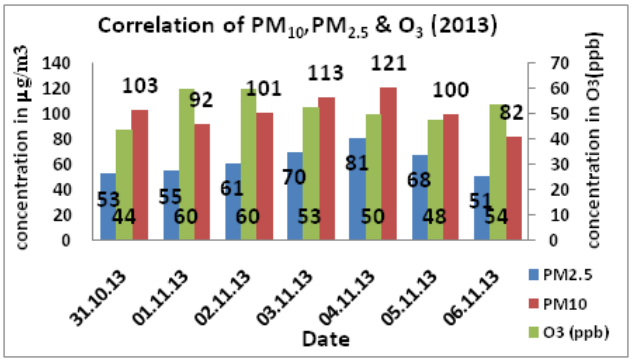


Figure 5. Daily variation of PM10 (2013)







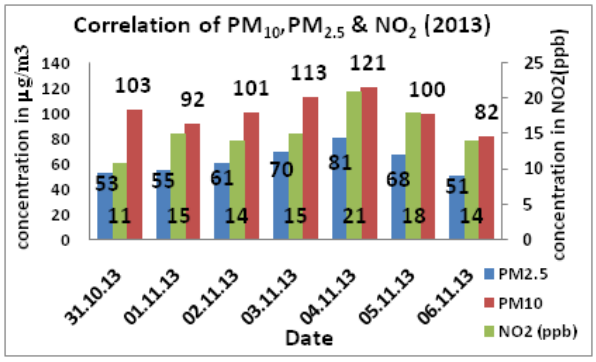


Figure 6. Comparison of PM_{10} and $PM_{2.5}$ with Tem., CO, O_3 and NO_2 (2013)

Table 3. Comparison of $PM_{2.5}$ and PM_{10} concentration on Diwali day (2012 and 2013)

Year	$PM_{2.5}$	PM_{10}
2012	106	142
2013	70	113

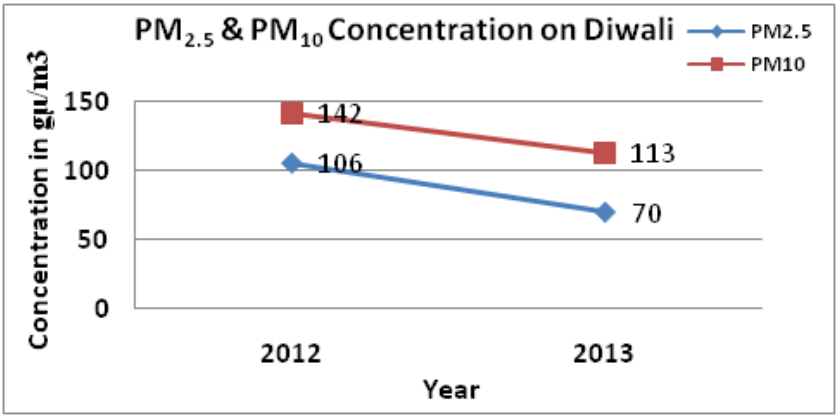


Figure 7. Comparison of PM10 and PM2.5 in two years

post- Diwali time. There is not much difference is observed in O_3 concentration.

Various studies conducted earlier also supports the above results. The result mentioned shows that the concentration of various parameters increases during Diwali day and post-Diwali days as compared to pre-Diwali day. Singh (2009) also found variation in the quality of various parameters during Diwali. There was a steep increase in $PM_{2.5}$ and PM_{10} concentration on the day of Diwali and after Diwali. Barman et al., (2009) and Thakur et al., (2010) also observed same trend of increase in PM_{10}, $PM_{2.5}$ and other parameters during Diwali due to excessive use of firecrackers. The studies during Diwali conducted by Vyas and Saraswat (2012), Chatterjee et al., (2013), Khan et al., (2013) and several other workers have found the increase in concentration of various parameters during Diwali period.

Matching result are also obtained by various workers i.e. increase in the $PM_{2.5}$ and PM_{10} levels Doing to Diwali and After Diwali in different part India and other country as mentioned earlier.

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