Depawali Festival Day Lead Concentration in Air -A Case Study

Balakrishna Gurugubelli
School of studies in Chemistry
Pt. Ravishankar Shukla University
Raipur 492010

Abstract

The components and quantities of atmospheric dusts during the Depawali festival activities have been assessed in Satna District, Madyapradesh, India, in the year 2013. The toxic metal Lead (Pb) and PM10 has been analyzed and found high concentrations. The study period has been classified as normal day, pre depawali day, depawali day and post depawali day and data collected for 24 hrs. The results during the study have shown that the high concentrations are found in night time. The Pb and PM2.5 concentrations are found several folds higher than normal day during fireworks.

Keywords: Lead, PM2.5, fireworks

1. Introduction

Depawali is a festival of lights and is celebrating all over in India in winter months of October/November. Atmospheric particulate pollutants, specifically heavy metals and trace elements derived from different anthropogenic sources, induce a variety of health effects which are currently considered as major problems in the highly urbanized regions of the world.

Trace gases, particulate matters and toxic metals are emitted into the atmosphere due to firework activities, which causes dense cloudy smoke in the atmosphere (Hirai et al., 2000; Ravindra et al., 2003; Kulshrestha et al.,2004; Drewnick et al., 2006; Tripathi and Gautam, 2007; Dwivedi et al., 2008). Fire work activity on new year eve in Oahu causes an increase in TSPM in atmosphere by 300% at 14 locations and by 700% lung penetrating size range at one location (Bach et al. 1975). Drewnick*et al.* (2006) showed the effect of firework activities during New Year's Eve in Mainz, Germany. Vecchi*et al.* (2008) observed high load of heavy metals due to firework activities during the celebration of victory of FIFA world Cup in the year of 2006 over Italy. It has also been observed the high loading of heavy metals during "Las Fallas" celebration famous for its firework displays in Spain (Moreno *et al.* 2007). Short term variation in air quality and PM10 and TSPM increase in Hissar city (India) during depawali festival has observed by Ravindra *et al.* (2003). High levels of trace metals in ambient air due to fireworks in Hyderabad has been identified by Kulshrestha*et al.* (2004). Barman et al.(2008, 2009) reported the sudden increase in PM2.5 concentration in air in Lucknow city due to firework activities during Diwali festival. Effect of firework activities during Diwali on surface Ozone levels has been reported in Delhi (Gangulyet al., 2009; Attriet al., 2001).

In India, 30 to 40% increased hospital cases of respiratory diseases, wheezing, exacerbation of the bronchial asthma and bronchitis patients of all age and sex groups, irrespective of a family history of asthma or not, are reported during the Diwali festival (Clark, 1997). So many studies has been done on air quality, particulate matter concentration in the atmosphere and toxic metal concentration (Balakrishna et al., 2013, Balakrishna and Pervez, 2009, Deb et al., 2002, Balakrishna et al., 2011, Sharma and Pervez 2004). A very few studies are there on heavy metal concentration during depawali festival. The present study will show the concentration levels of lead in one day PM2.5 concentration.

2. Methodology

2.1 Study Design

The study has been done in Satna, Madhyapradesh (24.34°N 80.55°E) cental India. Sampling has been done in the main market to know the status of the air pollution during fireworks. The hourly base sampling has been started on October 31st to 6th November 2013 and samples were collected for 24 hrs from 6 AM to 6AM.

The collected data has been divided into two parts for day time (6AM to 6PM) and night time (6 PM to 6 AM). To identify the effect of Depawali festival (3rd November 2013), 2nd November and 4th November has been classified as pre and post Depawali days and 31st October and 6th November has been classified as normal days.

2.2 Sampling Design

Sampling has been done using respirable dust sampler (RDS) (Envirotech, Model APM 460) with a flow rate 1.1 m3/min. Sampler has been placed on the top of the building which has height ~ 20 foot from the surface. The dust samples were collected on filter paper (EPM 2000 filter paper from Whatman of 8 × 10 inch dimension), and dust fractions which has size more than 10 µm were collected in a cup placed under the cyclone. The filters were placed in hot air oven for 1 hr at 105°C before sampling to avoid moisture in the filter paper. After sampling the filter papers were immediately transfer to laboratory and kept in desiccator to avoid the absorbed water and then weighed using digital analytical balance (Sartorius, Model ME 235). The weight (µg) of PM2.5 has been identified by difference between initial and final weight of the filter paper and the conversion for $\mu g/m^3$ done by dividing by total volume of air (m^3).

2.3 Chemical Analysis

To prevent contamination specialized cleaning and sampling techniques were used during all stages of sample collection. All equipments and containers used for sampling were cleaned using a dilute liquid soap followed by a hydrochloric acid solution and multiple rinses in ultra pure, deionized (DI) water, following standard protocols.
The sampling filter papers were stored in zippered polyethylene. All collected samples stored at 5 ·C or less until chemical analysis. The samples were digested in a Teflon digestion bomb by adding nitric acid (HNO3) and hydrogen peroxide (H2O2) (3:1). The Teflon bomb was then kept in an electric oven at 60 _C for five hour. After the digestion Teflon bomb was cooled, content was filtered in a volumetric flask and washed with dilute nitric acid (HNO3). Final volume of the digested samples was made to 25 ml using double distilled water. Digested samples and soluble fraction of dusts collected during sampling were analyzed for total Pb content using inductive coupled plasma-atomic emission spectrophotometer (ICP-AES) (JOBIN-YVON HORIBA ICP Spectrometer Version 3.0). To avoid spectral and chemical interference Lead analysis has been carried out at a wavelength of 189.042 nm. Calibration of instrument was done using Merck standard ICP solution of concentration range 0.1–10 ppm. The power used for analysis is 1200W; plasma gas flow rate is 12 l min−1.

3. Results and Discussion

3.1 PM2.5 Concentrations

A 24 hrs (6AM to 5AM) sampling plan on 1 hr basis for four days has been performed to identify the PM2.5 concentration and shown in **figure 1**. In the study period (pre, post and Depawali day), it has been observed high concentration during night time than morning time and increases the concentration with the firework activities shown in **Table 1**. High concentration has been found on Depawali night due to the contribution of fireworks and the scenario gradually decreased on post depawali.

The 12 hours (day time and night time) concentration of PM2.5 during the study period (Pre, Post, Normal and Depawali day) have been observed and furnished in **table 1 and Figure 1**. The 24 hr Geometrical mean concentrations of PM2.5 for the study period is; normal day 67.29 $\mu g/m^3$ followed by pre depawali 89.54 $\mu g/m^3$depawali day 210.62 $\mu g/m^3$ and post depawali 156.43 $\mu g/m^3$. To identify the better concentration levels of PM2.5 we have furnished the 12 hrs (day time and night time) concentration during the study and shown in the **Table 1 and Figure 2**. The maximum day time PM2.5 concentration has been observed on post depawali day (121.76±34.80 $\mu g/m^3$) followed by Depawali day (119.15±50.47 $\mu g/m^3$), pre depawali (72.91±16.53 $\mu g/m^3$) and normal day (58.61±8.86 $\mu g/m^3$). This is due to the night time firework concentration on depawali day influence on next day time particulate matter concentration. The night time concentrations of PM2.5 are comparatively higher than day time. This is due to the temperature decrease ~ 5-7 ^{O}C and lower wind speed the particles are accumulated near to the surface. It has been observed during the study the PM2.5 concentration at night on pre depawali, Depawali day and post depawali day are respectively 2, 7 and 4 times higher than normal permissible limits (100 µg/m3 as per NAAQS). This is due to the firework activities are high on these three days. During and after fire works the dust concentration has showed that the depawali day is significantly different from other days. The comparison has shown in the **table 2** which indicates the clear picture of the accurate concentration on depawali night.

3.2 Lead Concentration Levels in PM2.5

Hourly collected dust has been sent to the laboratory for total lead analysis for the study period. The results have shown the different lead concentration levels furnished in **Figure 3and table 3**. It has been observed that the pre depawali, depawali day and post depawali day lead concentrations are more dominating than normal day lead concentrations. The 24 hr lead concentration has found high on post depawali day with equal standard deviation (3.440±3.267), which indicates the high concentration of lead has been found in all 24 samples of the day. This is due to the fire works on depawali day which covers the high lead concentration on post depawali day time. The normal day lead concentrations are comparatively very low i.e 0.579±0.207, where asdepawali day lead concentration has noted with high standard deviation (3.738±5.022), which shows the irregular high and low concentrations of lead has been observed on the day. The 12 hr lead concentration has shown the original scenario of the study. The normal day and pre depawali day average lead concentration is 0.617 $\mu g/m^3$ and 1.063 respectively which are close to the standers, where asDepawali day and post depawali day has shown average lead concentration respectively 5.787 and 4.422 $\mu g/m^3$ which are approximately 6 and 4 times higher than the permissible limits. The heighst concentration has been noted on depawali night time (175.336 $\mu g/m^3$) which is seventeen times higher than permissible limits. This is clearly indicate that the firework contribution on lead concentration level in atmosphere and the night time lead concentration is 5 folds higher than day time concentration shown in **Table 3**. This lead level has shown similar levels with the work done in Howrah (**Thakur et al., 2010**) and eight folds higher than Delhi (**Perrino et al., 2011**).

To identify the clear picture we have made classification of fire working hours and after fire working hours and shown in **table 4**. It has been clearly identified that the depawali day fire working hours has shown the highest concentration (12.236±3.410) of lead than other working hours. The range has shown the severity of the concentration in the study period.

4. Conclusion

In the conclusion it has been found that, fire work activities have increased the lead (Pb) and PM2.5 concentration in the atmosphere. The highest PM2.5 concentration has found 711.02 $\mu g/m^3$ on depawali night time which is 3.5 times higher than night time PM2.5 concentration of normal day and the lead metal concentration increase (17.336 $\mu g/m^3$) shown nearly 20 times higher than average night lead concentration of normal day. The normal day PM2.5 and lead concentrations shown similar behavior till predepawali day time concentrations, where as the pre depawali night time has started to shown a new trend in the both concentrations due to some initial fire working actions. It has also been observed that that there is a strong correlation of night time high concentration of the PM2.5 and lead with next day daytime concentrations due to strong effect of fireworks. This type of short time concentration of toxic metal may cause severe and acute health effects. The unfavorable atmospheric conditions (viz: low wind speed, low temperature) favors the toxic pollutants to accumulate near the surface till the next day morning time, due to this the health risk rate will be increase. So it is very necessary to control the emission of toxic metals for the benefit public and society. To reduce these health effects it is very important to educate the public regarding the health effects of the fireworks; along with this, encouraging flying crackers, prohibition on high smoke firecrackers and reduce and fixed specific time for firecrackers along with different time schedule for different areas to reduce bulk atmospheric pollution levels and also for safe health of public.

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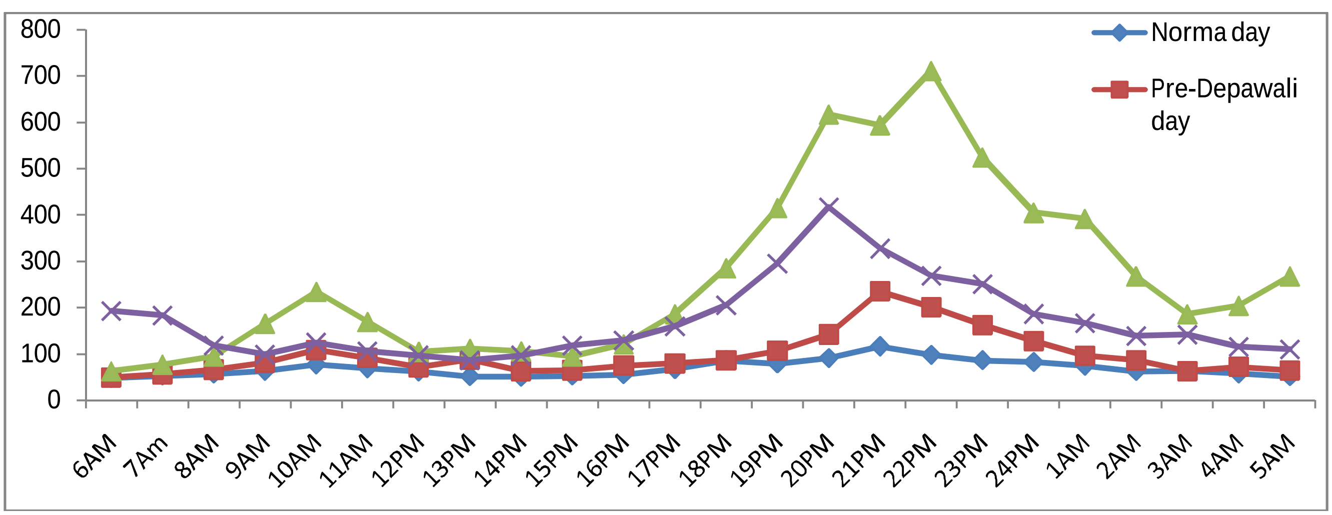

Figure 1: Distribution of the Particulate Matter during the Study Period

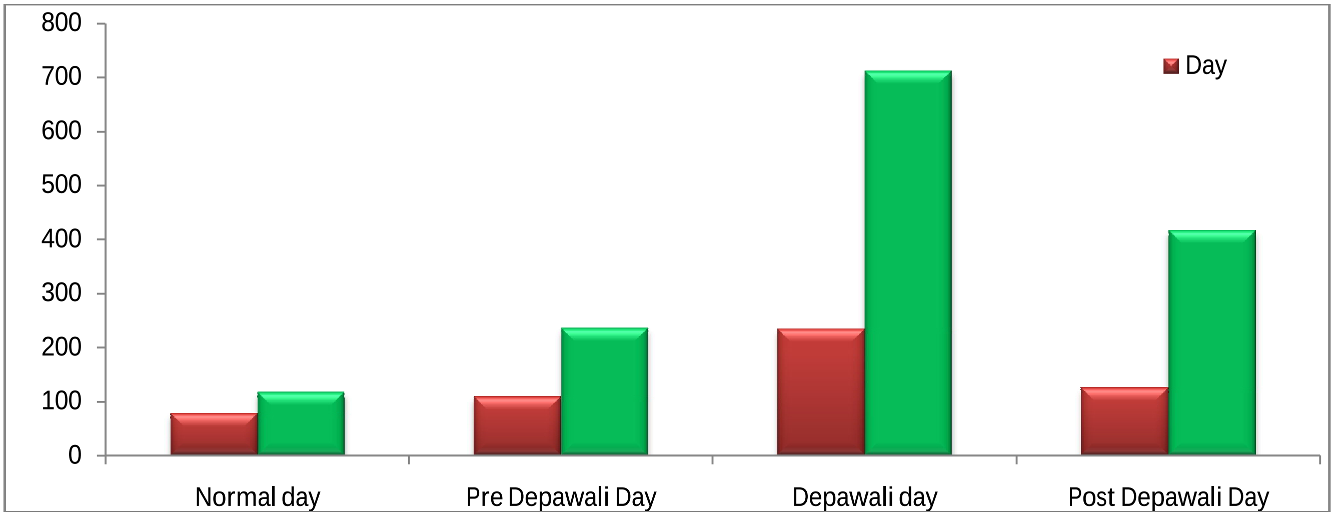

Figure 2: Particulate Matter Concentrations at Day and Night Time during the Study Period

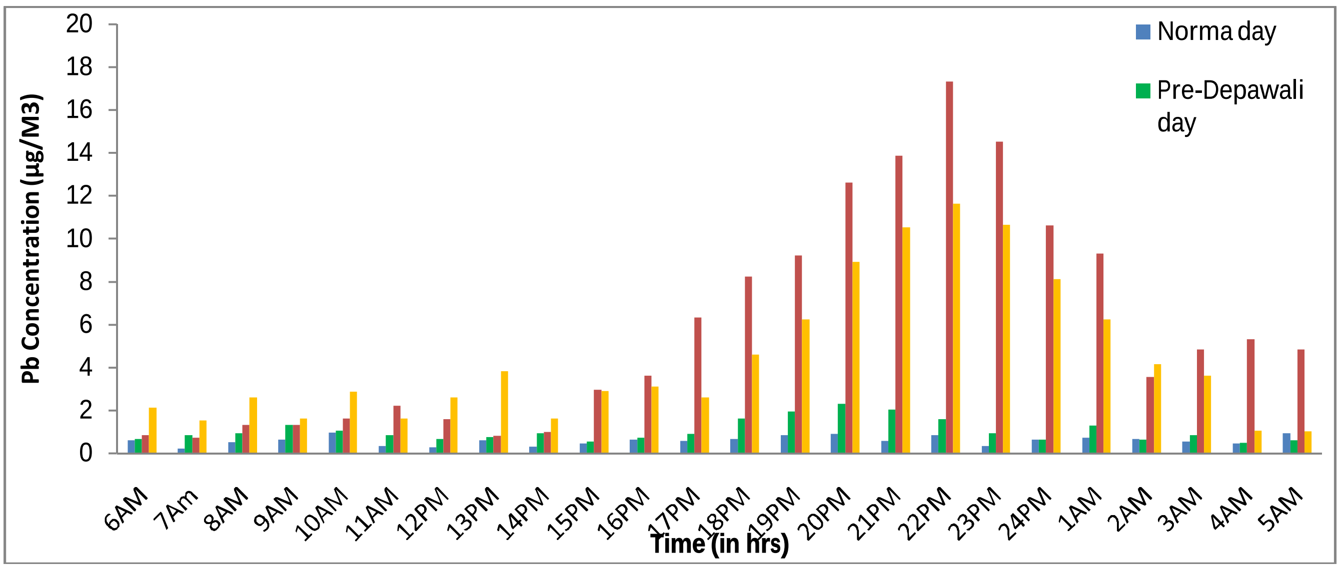

Figure 3: Hourly Lead Concentrations throughout the Study

Table 1: PM2.5 Concentration for 24 hr and 12 hr (Day and Night) of Study Period (µg/m^3)

24 hrs (n=24)					**12 hrs (n=12)**							
					Normal Day		**Pre Depawali Day**		**Depawali Day**		**Post Depawali Day**	
Statistics	**Normal Day**	**Pre Depawali Day**	**Depawali Day**	**Post Depawali Day**	**Day Time**	**Night Time**	**Day Time**	**Night Time**	**Day Time**	**Night Time**	**Day Time**	**Night Time**
Geomean±SD	67.29± 17.52	89.54± 46.39	210.62± 189.12	156.43 ±84.53	58.61 ±8.86	77.25± 18.55	72.91± 16.53	109.95 ±55.53	119.15 ±50.47	372.32± 172.88	121.76 ±34.80	200.96 ±94.96
Min	48.54	49.28	63.52	86.55	48.54	51.64	49.28	62.48	63.52	186.57	86.55	109.35
Max	116.52	235.19	711.02	416.57	77.51	116.52	108.51	235.19	234.09	711.02	192.64	416.57
Range (Max-Min)	67.98	185.91	647.5	330.02	28.97	64.88	59.23	172.71	170.57	524.45	106.09	307.22

Table 2: PM2.5 Concentrations during Fire Work Hours and after Firework Hours (μg/m^3)

During firework hours 6PM-11PM (n=6)					**After firework hours 11PM-5AM (n=6)**			
Statistics	**Normal Day**	**Pre Depawali Day**	**Depawali Day**	**Post Depawali Day**	**Normal Day**	**Pre Depawali Day**	**Depawali Day**	**Post Depawali Day**
Geomean±SD	92.34±13.08	147.02±56.24	503.22±153.19	287.00±72.78	64.63±11.31	82.23±24.80	275.47±92.35	140.72±29.59
Min	86.32	86.59	285.31	205.37	51.64	62.48	186.57	109.35
Max	116.52	235.19	711.02	416.57	82.55	128.08	405.26	186.54
Range (Max-Min)	30.2	148.60	425.71	211.20	30.91	65.60	218.69	77.19

Table3: Lead Concentrations for 24 hr and 12 hr (Day and Night) of Study Period (μg/m^3)

24 hrs (n=24)					**12 hrs (n=12)**							
					Normal Day		**Pre Depawali Day**		**Depawali Day**		**Post Depawali Day**	
Statistics	**Normal Day**	**Pre Depawali Day**	**Depawali Day**	**Post Depawali Day**	**Day Time**	**Night Time**	**Day Time**	**Night Time**	**Day Time**	**Night Time**	**Day Time**	**Night Time**
Geomean±SD	0.579± 0.207	0.969± 0.504	3.738± 5.022	3.440± 3.267	0.496± 0.206	0.676± 0.180	0.845± 0.204	1.112± 0.636	1.638± 1.618	8.533± 4.414	2.336± 0.727	5.067± 3.631
Min	0.251	0.498	0.745	1.041	0.251	0.365	0.558	0.498	0.745	3.565	1.558	1.041
Max	0.982	2.326	17.336	11.625	0.982	0.954	1.332	2.326	6.325	17.336	3.845	11.625
Range (Max-Min)	0.731	1.828	16.591	10.584	0.731	0.589	0.774	1.828	5.580	13.771	2.287	10.584

Table 4: Lead Concentrations during Fire Work Hours and after Firework Hours (μg/m^3)

During firework hours 6PM-11PM (n=6)					**After firework hours 11PM-5AM (n=6)**			
Statistics	**Normal Day**	**Pre Depawali Day**	**Depawali Day**	**Post Depawali Day**	**Normal Day**	**Pre Depawali Day**	**Depawali Day**	**Post Depawali Day**
Geomean±SD	0.684±0.209	1.689±0.478	12.236±3.410	8.342±2.770	0.669±0.163	0.732±0.282	5.950±2.843	3.077±2.817
Min	0.365	0.956	8.235	4.625	0.484	0.498	3.565	1.041
Max	0.926	2.326	17.336	11.625	0.954	1.295	10.632	8.132
Range (Max-Min)	0.561	1.370	9.101	7.000	0.470	0.797	7.067	7.091