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RESEARCH ARTICLE

STATUS OF AIR POLLUTION DURING FESTIVAL OF LIGHTS (DIWALI) IN JHANSI, BUNDELKHAND REGION, INDIA

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ABSTRACT

Diwali (Deepavali) is the festival of light and is celebrated with great enthusiasm all over India every year. Bursting crackers is the most prominent activity of Diwali. These firecrackers when burnt releases various gaseous and particulate air pollutants and toxic metals to significant quantity and degrades the air quality as a whole. The present study deals with the impact of bursting crackers and fireworks on the ambient air quality of Jhansi city during Diwali festival in Nov 2013. In the present study, SO_2, NO_2, RSPM and SPM were estimated at residential and commercial site during the day and night times for pre-Diwali, Diwali and post-Diwali *i.e.* from 1-5th Nov 2013. On Diwali, the level of SO_2, NO_2 and RSPM and SPM values were found in commercial and residential area to be 32.12, 60.26, 387.37 and 723.24 μg/m^3 and in residential area to be 28.30, 52.69, 312.51, 618.31 μg/m^3 respectively, which were very high when compared with any normal day of commercial area (7.18, 21.08, 126 and 257.21 μg/m^3 respectively) and in residential area (6.28, 17.10, 107 and 214.67 μg/m^3 respectively). On Diwali and after Diwali, the values of SO_2, NO_2 within range but RSPM and SPM were found to be much higher than the standard value of NAAQS. Hence, in the present study, crackers and fireworks were found to be the chief sources of air pollution during the Diwali festival. Even though the impact of Diwali is short term, but the short term exposure of these pollutants above the standard values causes health complicatio

INTRODUCTION

In India, Festival of Light (Diwali) is an important occasion celebrated every year during October or November but we end up celebrating it with waste and pollution instead. Large quantities of fireworks are displayed during the festival. For most people lighting of fire crackers is the highlight of Diwali. Brighter the sparkles, louder the noise, greater the thrill. Bursting crackers is being used as a competition and a status indicator. In fact to many of us there aesthetic forms of lights seem so appropriate and most essential when celebrating the festival of light, but little do people realize that in our increasingly populated and polluted cites the temporary joy of watching the fume crackers causes intense air pollution. Fireworks are made of toxic chemicals bursting a cracker releases sulphur compounds, heavy metal, coal, ozone, sulphur dioxide, nitrate oxide and other chemical elements into the air. Chemicals like barium aluminium, rubidium, cadmium, mercury and bronze are added to crackers to emit colours and sparks and inhaling these chemicals may causes health complications. One diwali night causes as much damage of the ecology a regular pollution does over the span of year.

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In California, USA a study following the Fourth of July holiday reveals significant increase in the levels of ambient air magnesium, aluminum, potassium lead, barium, strontium, and copper. The study also reports the original chemical composition and particle size of typical firework mixtures *(Liu et al., 1997)*. A laboratory study revealed that highly toxic contaminants like polychlorinated dioxins and furans are produced during the display of fireworks like "blue lightning rockets" and "fountains" *(Fleischer et al., 1999)*. The chemical composition and chemically resolved size distributions of fine aerosol particles were measured during the New Year's 2005 fireworks in Mainz, Central Germany *(Drewnick et al., 2006)*. A detailed study of air pollution caused by firework display during lantern day festival in Beijing reported 57, 25 and 183% increase in SO_2, NO_2, and PM_{10} levels respectively over previous day. Analysis of different elements and ions in fine particulates revealed that over 90% of the total mineral aerosol and 98% of Pb, 43% of total carbon, 28% of Zn, 8% of NO_3^-, and 3% of SO_4^{2-} in $PM_{2.5}$ were from the emissions of fireworks on the lantern night *(Wang et al., 2007)*. In Italy, a study on chemical–physical properties of airborne particles during a fireworks episode reported one hour concentration of elements like Sr, Mg, Ba, K and Cu increased by 120, 22, 12, 11 and 6 times *(Vecchi et al., 2008)*. On 2nd January, 2005 the Victoria Advocate reported firework display on New Year

celebration in México City "left a dense gray pall over much of city" and described the air as more polluted over a normal Saturday. Ozone level was reported to climb 190 on a scale with normal cut–off level of 100 *(Victoria Advocate, 2005)*.

It is estimated that the annual carbon dioxide emissions from fireworks is 60,340 tons or the same emissions from 12,000 cars on the road for a year. If one suggests that planting trees is a solution, then, please be informed that it would take the entire lifetime of 5,000 trees to offset the 60,000 tons of carbon emissions produced in this one day. Not only it pollutes the environment, it also causes many deadly air-borne diseases. The objective of the present study was set to monitor air quality parameters such as SPM (Suspended Particulate Matter), PM_{10} or RPM (Respirable particulate matter), Sulfur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) on and around the day of Diwali in the year 2013. The results are compared with typical winter day concentration levels for the chosen parameters and with the ambient air quality standards. The probable health impact for observed short–term degradation in air quality is also estimated in terms of percentage increase in relative risk of mortality and morbidity.

MATERIALS AND METHODS

Study Area

Jhansi city, situated between the rivers Pahunj and Betwa is a symbol of bravery, courage and self respect. It is said that in ancient times Jhansi was a part of the regions Chedi Rashtra, Jejak Bhukit, Jajhoti and Bundelkhand. It is well known district of Bundelkhand region of Uttar Pradesh with a geographical area of 502.75 thousand hectare. The district is situated in the South West corner of the region at 24º11' - 25º57' N latitude and 78º10' - 79º23' E longitudes. Population of Jhansi is near about 4, 79,612. The western area of the district is covered with hillocks. Jhansi is located in the plateau of central Indian area dominated by rocky reliefs and minerals underneath the soil. The city has a natural slope in the north as it lies on the south western border of the vast *Tarai* plains of Uttar Pradesh.

Analytical Design

To see the impact of bursting of crackers etc. on air quality the 24 hrs continuous ambient air quality monitoring was carried out at Jhansi city, U.P. In the present study ambient air quality was monitored by using Respirable Dust Sampler' (Envirotech APM- 460 NL) for suspended particulate matter and for gaseous pollutants.

Sulphur Dioxide (SO_2)

Sulfur dioxide affects human health when it is breathed in. It irritates the nose, throat and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest. The effects of sulfur dioxide are felt very quickly and most people would feel the worst symptoms in 10 or 15 minutes after breathing it in. Those most at risk of developing problems if they are exposed to sulfur dioxide are people with asthma or similar conditions. Sulphur dioxide was analysed by modified *West and Gaeke, (1956)* pararosaniline method. A known quantity of air passed through the impinger of high volume sampler. The SO_2 in the ambient air was absorbed in the solution of potasium tetrachloromercurate. A dichlorosulphitomercurate complex was formed, which was made to react with pararosaniline and formaldehyde to form intensely colored pararosaniline methylsulphonic acid. The absorbance of the solution was measured at wavelength of 560 nm.

Nitrogen Dioxide (NO_2)

Small levels of NO_2 can cause nausea, irritated eyes and/or nose, fluid forming in lungs and shortness of breath**.** Breathing in high levels of NO_2 can lead to burning spasms, swelling of throat, reduced oxygen intake, a larger buildup of fluids in lungs and/or death**.** NOx, plus other ground-level ozone, can cause other major respiratory problems in high levels. It can react with aerosols from aerosols cans and also cause respiratory problems**.** NO_2 concentration in the ambient air was monitored by sodium arsenite method (*Jacobs, M. B. and Hochheiser, S. 1958*). NO_2 was absorbed in absorbing solution of sodium hydroxide and sodium arsenite to form a stable solution of sodium nitrite and was determined at a wavelength of 540 nm.

Respirable Suspended Particulate Matter (RSPM) and Suspended Particulate Matter (SPM)

For Suspended particulate matter, the ambient air was filtered through glass micro fibre filter paper GF/A (20.3 x 25.4). The SPM present in the air thus got deposited on the surface of filter paper. The filter paper was reweighted after sampling, which gives the amount of SPM in the air during that time period. This concentration of the particulate matter in ambient air was then computed on the net mass collected divided by the volume of air sampled.

RESULTS AND DISCUSSION

Trapping of pollutants due to burning of fire crackers under cold conditions during Diwali promotes the formation of smog that stays close to the ground for long time before its dispersion into the atmosphere. The smog is a combination of fog and smoke or other air pollutants. It is created when moisture level is high in the atmosphere. It does not allow the tiny particles of pollutants to dissipate, and tiny water droplets carrying fine particles of pollutants and dust remain suspended in the atmosphere. Smog may worsen the condition of patients with lungs, heart and nervous system diseases. The major pollutants were observed and were compared with that of normal day.

Respirable Suspended Particulate Matter (RSPM) and Suspended Particulate Matter (SPM)

There is only a small number of chemical species that typically constitutes a significant fraction of the Particulate Matter mass. Taking 1% of the mass as a lower limit, the species of interest include a few elements (aluminum, silicon, iron, calcium, potassium and magnesium), the main anions and cations (chloride, nitrate, sulfate, carbonate, sodium and ammonium) and elemental carbon. Although organic substances altogether constitute a very high percentage of PM (20–60%), the number of individual organic species is extremely high (hundreds–thousands) and none of them individually constitutes more than 1% of the total mass; for this reason organic compounds are generally considered as a

Table 1. Showing value of Sox and NOx during Pre Diwali, Diwali and Post Diwali days in Residential and Commercial area

	S.No	Date	C.C	SOx 06am-10am	06am-10am	06am-10am	06am-10am	06am-10am	06am-10am	24 Hrs Avg	SD	NAAQS	NOx 06am-10am	06am-10am	06am-10am	06am-10am	06am-10am	06am-10am	24 Hrs Avg	SD	NAAQS	
	1.	1/11/13	C	12.3	12.5	12.7	12.4	12	11.5	12.23	.43		20	22	25	23	21	18	21.5	2.4		Pre Diwali
C	2.	3/11/13	C	26.4	28.3	29.5	35.5	37.2	35.2	32.12	4.4	80	48	54	58	65	67	72	60.26	8.93	80	Diwali
	3.	5/11/13	C	14.3	15.2	15.8	13.8	13.5	13	14.26	1.06		22	23	25	21	19	17	21.1	2.85		Post Diwali
	1.	1/11/13	C	7.4	7.6	7.8	7.5	7.3	7.8	7.5	0.2		19	20	22	21	20	18	20	1.4		Pre Diwali
R	2.	3/11/13	C	23	25	27	29	34	30	28.30	3.8	30	45	47	50	56	59	55	52.69	5.51	30	Diwali
	3.	5/11/13	C	8.1	8.4	8.7	8.5	8	7.6	8.2	.39		23	25	28	25	23	21	24	2.4		Post Diwali

All values in- **µg/m^3, SD-**Standard deviation, **NAAQS-** National Ambient air quality standard, **R-**Residential area, **C-** Commercial area

Table 2. Showing value of RSPM and SPM during Pre Diwali, Diwali and Post Diwali days in Residential and Commercial

	S.No	Date	C.C	RSPM 06am-10am	06am-10am	06am-10am	24 Hrs Avg	SD	NAAQS	SPM 06am-10am	06am-10am	06am-10am	24 Hrs Avg	SD	NAAQS	
	1.	1/11/13	C	128	148	116	130	16.16		249	288	226	254.33	31.34		Pre Diwali
C	2.	3/11/13	C	355	382	425	387	35.30	100	678	736	755	723	40.11	200	Diwali
	3.	5/11/13	C	131	149	119	133	15.7		256	291	238	261.66	26.95		Post Diwali
	1.	1/11/13	C	114	135	108	119	14.17		231	254	210	231.66	22.06		Pre Diwali
R	2.	3/11/13	C	291	312	335	312.51	22.52	75	565	615	675	618.33	55.05	100	Diwali
	3.	5/11/13	C	136	150	115	133.66	17.61		246	272	232	250.1	20.29		Post Diwali

area. All values in- **µg/m^3, SD-**Standard deviation, **NAAQS-** National Ambient air quality standard, **R-**Residential area, **C-** Commercial area

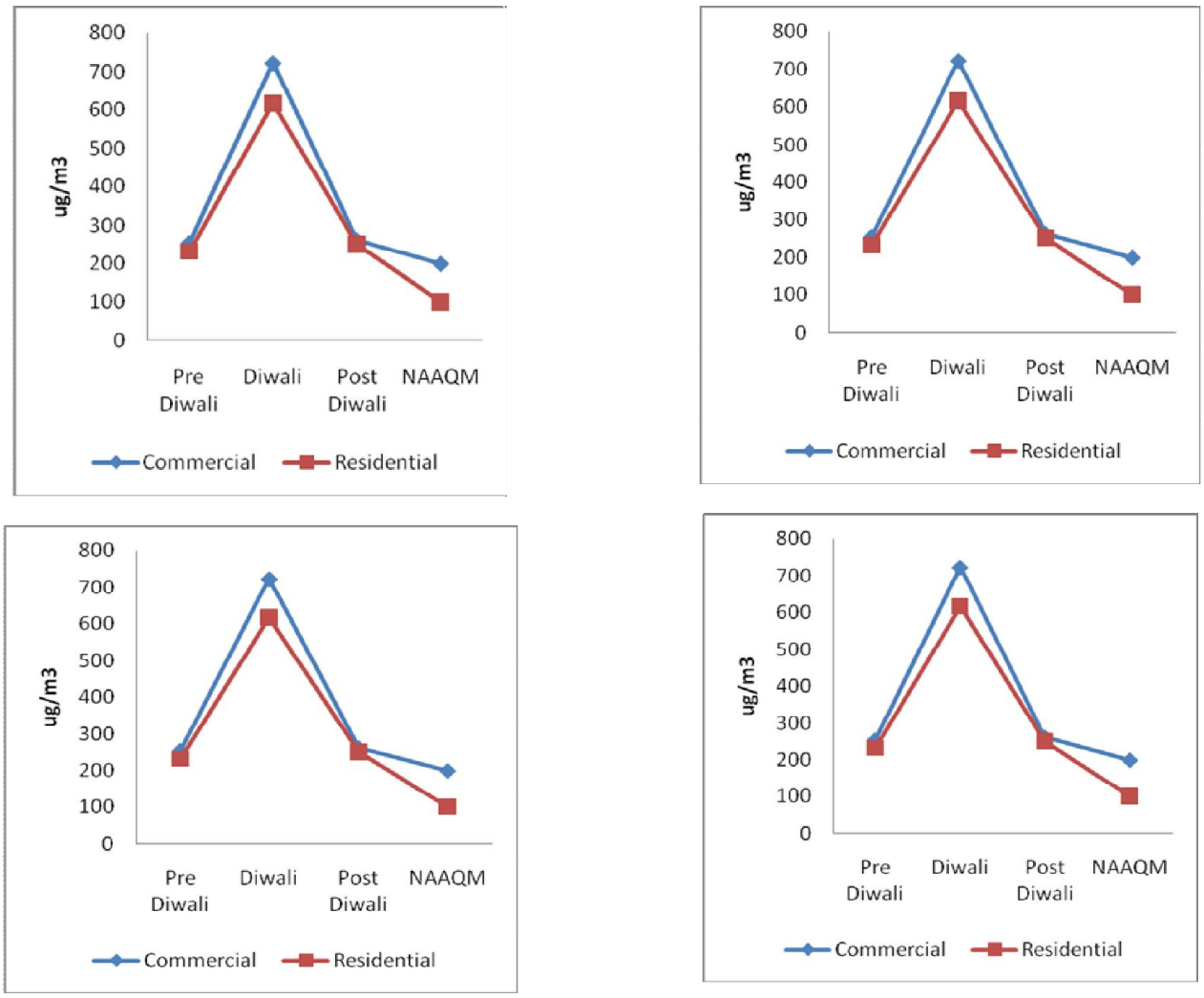

Fig. 2. Showing comparative values of a. SOx conc. b. NOx conc. c. RSPM d. SPM conc. during pre Diwali, Diwali and post Diwali days

whole (organic matter). The exposure to particulate matter is reported to have caused chronic respiratory and cardio–vascular diseases, alter host defense, damage lung tissue, lead to premature death and contribute to cancer *(Seaton et al., 1995; Bates, 1996; Pope et al., 2002)*. Particles with aerodynamic diameter less than 10μm (PM_{10}) only can be respired to reach to the lungs. Even finer fractions popularly known as fine particulate matter (FPM), with aerodynamic diameter less than 2.5μm ($PM_{2.5}$), can penetrate the lungs further to alveolar level and can aggravate the problem even more *(Dominici et al., 2006; Pope et al., 2006)*. Recent epidemiological studies clearly establish the relation between the harmful effects on human health and mortality with increased concentration of atmospheric particulates *(Dockery et al., 1993; Schwartz, 1993; Levy et al., 2000; Steib et al., 2002, 2003; Dominici et al., 2003; Katsouyanni et al., 2003; Pope et al., 2004; Anderson et al., 2005; Chen et al., 2005; Analitis et al., 2006; COMEAP, 2006; Pope and Dockery, 2006; Torén et al., 2007)*. RSPM (Respirable Suspended Particulate Matter) concentration increased upto approximately 3 times in commercial and residential area respectively (387 and 312 μg/m^3**)** on Diwali day and slightly increased during post-Diwali day **(**133.56 and 133 μg/m^3) with its comparison to a pre-Diwali (130 and 119 μg/m^3). The concentration of RSPM on Diwali day and after Diwali day was observed above permissible limit (100 and 75 μg/m^3). The pre-Diwali average concentration of RSPM during winter was slightly above the permissible limits. Same trend was found in Suspended Particulate Matter (SPM), the concentration increased upto approximately 3 times in commercial and residential area respectively (723 and 618 μg/m^3**)** on Diwali day and slightly increased during post-Diwali day **(**261.6 and 250.1 μg/m^3) with its comparison to a pre-Diwali (254 a and 231.66 μg/m^3). The concentration of RSPM on Diwali day and after Diwali day was observed above permissible limit (200 and 100μg/m^3).

Sulphur Dioxide (SO_2)

During Diwali day, the SO_2 concentration increased upto approximately 3 times in commercial area and 4 times in residential area (32.12 and 28.30 μg/m^3) to a typical normal day (12.23 and 7.5 μg/m^3). A day after Diwali, the concentration was observed 14.26 μg/m^3 in commercial area and 8.2 μg/m^3. The concentration of SO_2 was observed maximum at night during Diwali as compared to day time, which seems to be associated with increased fireworks and crackers during the night.

Nitrogen Dioxide (NO_2)

NO_2 concentration increased upto approximately 3 times in commercial and residential area respectively (60.26 and 52.69 μg/m^3**)** on Diwali day and post-Diwali day **(**21.1 and 24 μg/m^3) with its comparison to a normal day (21.5 and 20.0 μg/m^3).

Conclusion

Huge amount of crackers and sparkles are burnt on Diwali, hence high concentration of pollutants was observed on Diwali day along with decrease in temperature. During winter season there is increased atmospheric stability, which in turn allows for less general circulation and thus more stagnant air masses. It prevents an upward movement of air, hence atmospheric mixing is retarded and pollutants are trapped near the ground. *Kulshretha et al. (2004)* reported high levels of different trace elements in ambient air due to fireworks during Diwali festival. Lack of quality control of crackers in India lead to increased level of these pollutants. There is barely any regulatory framework to monitor the quality aspects the crackers. The toxic substances used in the firecrackers release toxic gases that are harmful to the health of all living beings. The levels of these pollutants observed during Diwali were found to be moderately high, which can be associated with serious health impacts. Excess emergency hospital admission has been reported during Diwali festival related to burn hazards and increased asthma. Even though the impact of diwali is short term, but the short term exposure of these pollutants has risen up the RSPM and SPM values 3 times above the standard values and probably it is the most significant reason of health complications during these days.

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