Ambient Air Quality
During
Pre-Diwali, Diwali and Post-Diwali Festival

November 2020

सीएसआईआर-भारतीय विषविज्ञान अनुसंधान संस्थान
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Introduction

Diwali, the biggest festival of India is popularly known as the "festival of lights". **It** is a major Hindu religious festival and is celebrated incessantly for five days during the lunar months of Ashvina and Kartika (October–November). The festival gets its name from the row (avali) of clay lamps (deepa). It is an auspicious festival that symbolizes the triumph of good over evil. The Hindus celebrate this festival to commemorate the return of Lord Rama back to his kingdom after 14 year-long period in exile and his victory over Ravana. For the people of Jain faith, this festival carries the essence of spiritual upliftment, because it inscribes the achievement of Nirvana or Moksha by Mahavira, the last Tirthankara. In India, Worshipping of Lord Ganesha and Goddess Lakshmi, the goddess of wealth, is an important ritual of Diwali that signifies welcoming of prosperity and wealth. Further on this occasion, spectacular lights, firecrackers, exchange of sweets and gifts mark the festival.

Mostly the burning of firecrackers occurs during evening hours and the burning of tons of firecrackers at a time make the atmosphere unlivable specially for old and younger individuals and people having asthma/bronchitis, respitory and cardiology problems. Different types of firecrackers release variety of pollutants into the lower atmosphere such as fine particles, polyaromatic hydrocarbons (PAHs), carbon monoxide, sulphur dioxide, oxides of nitrogen, carbon dioxide, barium nitrate; metals like lithium, aluminum, copper, zinc, lead, nickel, manganese, magnesium, cadmium, and many others chemical compounds toxic to human being and other animals.

During winter season, the Himalayan cold front hits the Northern parts of India quite early i.e November onwards and the night time temperature fall down quickly due to cold weather (low temperature and high humidity) and calm wind (low wind speed <0.4 m/s) condition. Therefore, pollution does not disperse easily and the pollutants slowly come down to the ground level/ breathing zone because of gravitational force. Further, during the night hours, pollutants absorb air moisture and condense others particles to increase its density and therefore, reduces its buoyancy and gradually pollutants settle

down over the night. Whenever, any firecracker bursts in the air, it consumes surrounding oxygen to burn and release pollutants. As a result the Oxygen levels drastically decrease in the atmosphere and become the cause of health problems. Decrease of oxygen levels in the breathing air and the increase of inhalable tiny particulates resulting from bursting of Diwali crackers may aggravate the Covid-19 pandemic problem.

Since bursting of firecrackers severely deteriorates the breathing zone air, CSIR-Indian Institute of Toxicology Research (CSIR-IITR), Lucknow had planned to conduct Air Quality survey at 7 locations (Aliganj, Vikasnagar, Gomtinagar, Charbagh, Aminabad, Alambagh and Amausi) of Lucknow city to assess the impact of firecrackers on the air quality during the Diwali festival, 2020.

Chemical Composition and Elements in Firecrackers

A lot of physics and chemistry involved in making fireworks. It colors come from the different temperatures of hot, glowing metals and from the light emitted by burning chemical compounds. Chemical reactions propel them and burst into special shapes. Here's an element-by-element look at what is involved in average firework.

Several of the metal salts that produce colors contain chlorine. Copper compounds produce blue colors in fireworks. Iron is used to produce sparks. The heat of the metal determines the color of the sparks. Lithium is a metal that is used to impart a red color to firecrackers. Lithium carbonate, in particular, is a common colorant. Magnesium burns a very bright white, so it is used to add white sparks or improve the overall brilliance of a firecrackers. Sodium imparts a gold or yellow color to fireworks, however, the color may be so bright that it masks less intense colors. Strontium salts impart a red color to fireworks. Strontium compounds are also important for stabilizing fireworks mixtures. Titanium metal can be burned as powder or flakes to produce silver sparks. Zinc is used to create smoke effects for fireworks and other pyrotechnic devices.

Firecrackers include oxidizers, which are substances that produce oxygen in order for burning to occur. The oxidizers are usually nitrates, chlorates or perchlorates. Sometimes the same substance is used to provide oxygen and color. Potassium helps to oxidize

firework mixtures. Potassium nitrate, potassium chlorate and potassium perchlorate are important oxidizers. Chlorine is an important component of many oxidizers in fireworks.

Phosphorus burns spontaneously in air and is also responsible for some glow-in-the-dark effects. It may be a component of a firework's fuel. Sulfur is a component of black powder. It is found in a firework's propellant/fuel.

Colouring Element used in Firecrackers

Sl. No.	Metal Name	Colour	Colour Imparted
1	Strontium	Red	
2	Copper	Blue	
3	Barium	Green	
4	Sodium	Yellow	
5	Calcium	Orang	
6	Titanium	Silver	

Green Crackers

To resolve the ever-growing problem of air pollution during the Diwali period, the Indian Government launched the concept of eco friendly crackers. In Green Crackers, commonly used polluting chemicals like aluminum, barium, potassium nitrate and carbon are removed or sharply reduced so that the emission scome down by 15 to 30%. CSIR-NEERI with other CSIR laboratories jointly have developed environment-friendly firecrackers and developed new formulations for reduced emission light and sound emitting crackers with a 30% reduction in particulate matter.

Objectives of the Survey:

The deteriorating urban atmosphere because of air pollution, the air quality of Lucknow city was monitored during Diwali period, 2020 with the following objectives:

- *to measure the concentrations of particulates (PM_{10} & $PM_{2.5}$), gases (SO_2 & NO_2) and levels of day and night time noise,*

- *to increase the public awareness about the spike of hazardous air pollution during Diwali due to fire the crackers* which *choke the city's atmosphere and*

- *to develop the air quality database during Diwali period,*

Results and Discussion:

The anlyses results of air quality in 7 locations are presented in Table 1 and Figure 1-3 Study reveals that the respirable particulate matters monitored during pre-Diwali, Diwali and post-Diwali are above the National Ambient Air Quality Standards of 60 and 100 $\mu g/m^3$ for $PM_{2.5}$ and PM_{10} respectively (Table 1).

PM_{10} Concentration During Pre-Diwali, Diwali, Post-Diwali

Pre-Diwali (13^{th} Nov. 2020), the 12 hr mean concentration of PM_{10} ranged 119.4 to 302.35 $\mu g/m^3$ and average 219.97.$\mu g/m^3$ during day time while 191.29 to 272.06$\mu g/m^3$ and average 228.44$\mu g/m^3$ during night time.

On Diwali (14^{th} Nov. 2020), the 12 hr mean concentration of PM_{10} ranged 202.25 to 259.13$\mu g/m^3$ and average 240.68 $\mu g/m^3$ during day time while 315.78 to 913.73 $\mu g/m^3$ and average 604.12 $\mu g/m^3$ during night time.

During Post-Diwali (15^{th} Nov. 2020), the 12 hr mean concentration of PM_{10} ranged 216.69 to 378.24 $\mu g/m^3$ and average 296.36$\mu g/m^3$ during day time while 139.90 to 270.91$\mu g/m^3$ and average 205.04 $\mu g/m^3$ during night time.

$PM_{2.5}$ Concentration During Pre-Diwali, Diwali, Post-Diwali

Pre-Diwali (13^{th} Nov. 2020), the 12 hr mean concentration of $PM_{2.5}$ ranged 59.94 to 145.88 $\mu g/m^3$ and average 102.6 $\mu g/m^3$ during day time while 52.78 to 151.41 $\mu g/m^3$ and average 105.11 $\mu g/m^3$ during night time.

On Diwali (14^{th} Nov. 2020), the 12 hr mean concentration of $PM_{2.5}$ ranged 48.17 to 164.77 $\mu g/m^3$ and average 121.51 $\mu g/m^3$ during day time while 173.63 to 652.86 $\mu g/m^3$ and average 402.22 $\mu g/m^3$ during night time.

During Post-Diwali (15^{th} Nov. 2020), the 12 hr mean concentration of $PM_{2.5}$ ranged 112.82 to 224.57 $\mu g/m^3$ and average 161.82 $\mu g/m^3$ during day time while 78.85 to 141.16 $\mu g/m^3$ and average 100.95$\mu g/m^3$ during night time.

On Diwali night, the level of PM_{10} had suddenly increased to 604.12 µg/m^3 i.e. increased by 164 % from 228.44 µg/m^3 over the pre-Diwali night and reduced to 205.04. µg/m^3 during post-Diwali night.

On Diwali night, the level of $PM_{2.5}$ had suddenly increased to 402.22 µg/m^3 i.e. increase by 282 % from 105.11 µg/m^3 over the pre-Diwali night and reduced to 100.95. µg/m^3 during post-Diwali night.

In case of SO_2, the mean level was found to be within prescribed limits. However, mean level of SO_2 on the Diwali night increased to 44.54 µg/m^3 i.e. increase of 171% from 16.46 µg/m^3 from pre-Diwali night.

The mean level of NO_2 was found to be within prescribed limits. On Diwali night the mean NO_2 value increased to 90.21 µg/m^3 from 42.48 µg/m^3 i.e. increase of 113% over the pre-Diwali night.

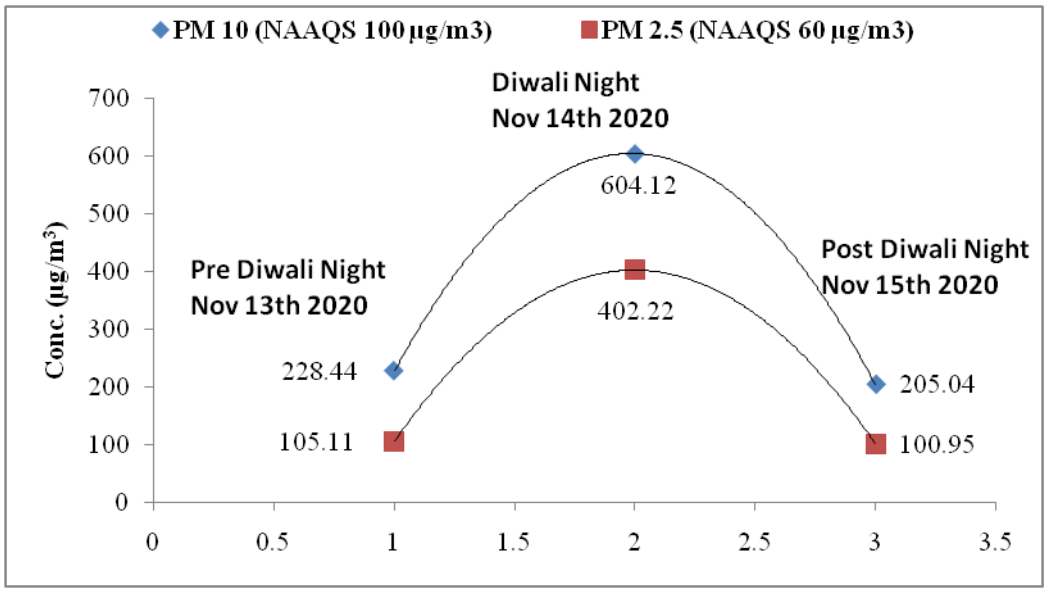

Fig. 1. Profile of respirable particulates (in µg/m^3) during the night time of Diwali Festival.

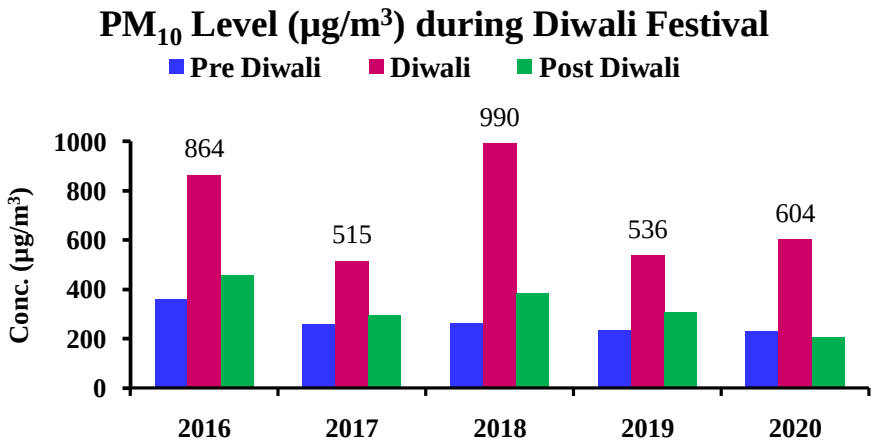

Fig. 2. Levels of respirable particulates (PM_{10}) concentration during 2014, 2015, 2016, 2017, 2018 2019 and 2020 (Night time Diwali Festival).

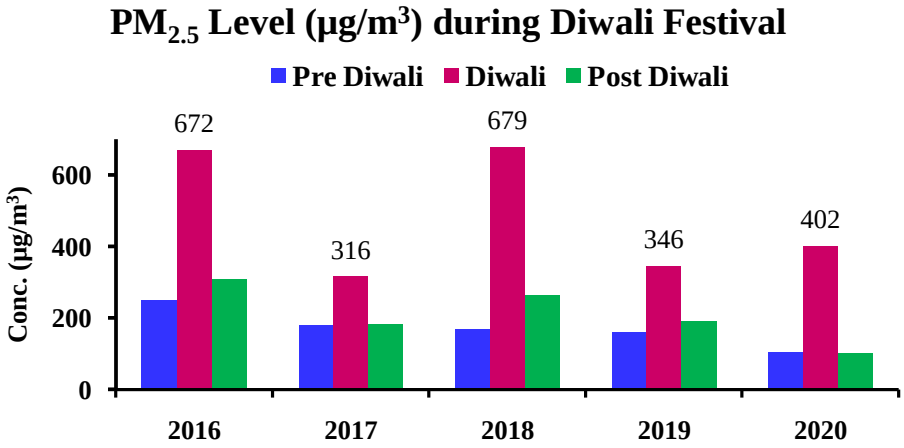

Fig. 3. Levels of respirable fine particulates ($PM_{2.5}$) concentration during 2014, 2015, 2016, 2017, 2018 2019 and 2020 (Night time Diwali Festival).

Table 1. CSIR-IITR Diwali 2020 Pollution Survey

Locations	**Pre-Diwali 2020** (November 13th 2020)		**On-Diwali 2020** (November 14th 2020)		**Post-Diwali 2020** (November 15th 2020)	
	Day (6:00 am to 6:00 pm)	Night (6:00 pm to 6:00 am)	Day (6:00 am to 6:00 pm)	Night (6:00 pm to 6:00 am)	Day (6:00 am to 6:00 pm)	Night # (6:00 pm to 6:00 am)
Pollutant : PM_{10} ($\mu g/m^3$)						
Aliganj	174.57	191.29	271.41	315.78	217.00	139.90
Vikas Nagar	184.72	217.36	248.94	771.04	354.72	228.72
Gomti Nagar	119.42	240.42	232.58	647.36	328.18	248.41
Charbagh	241.34	272.06	259.13	814.74	378.24	211.38
Alambagh	286.03	200.89	228.87	369.54	294.48	170.96
Aminabad	302.35	229.22	202.25	913.73	285.18	270.91
Amausi	231.38	247.84	241.58	396.63	216.69	165.01
Average	**219.97**	**228.44**	**240.68**	**604.12**	**296.36**	**205.04**
Pollutant : $PM_{2.5}$ ($\mu g/m^3$)						
Aliganj	99.19	52.78	48.17	173.63	123.34	95.41
Vikas Nagar	59.94	117.56	144.58	255.58	112.82	92.70
Gomti Nagar	93.23	101.26	80.41	652.86	206.89	111.81
Charbagh	145.88	151.41	164.77	568.05	244.52	101.94
Alambagh	119.68	117.57	161.34	451.92	155.58	141.16
Aminabad	108.00	106.83	128.65	537.27	157.68	84.81
Amausi	92.26	88.35	122.68	176.25	131.88	78.85
Average	**102.6**	**105.11**	**121.51**	**402.22**	**161.82**	**100.95**
Pollutant : SO_2 ($\mu g/m^3$)						
Aliganj	16.62	15.75	12.42	42.07	32.96	16.42
Vikas Nagar	14.99	23.58	29.07	43.61	34.17	16.28
Gomti Nagar	17.04	18.09	13.84	47.88	19.83	18.28
Charbagh	11.08	15.63	13.57	54.46	22.62	18.71
Alambagh	15.14	10.22	25.12	40.42	26.01	18.36
Aminabad	18.53	14.15	10.75	42.64	30.55	13.11
Amausi	25.31	17.83	37.21	40.72	32.19	15.06
Average	**16.96**	**16.46**	**20.28**	**44.54**	**28.33**	**16.6**
Pollutant : NO_2 ($\mu g/m^3$)						
Aliganj	34.02	42.26	43.39	96.95	64.59	58.08
Vikas Nagar	37.28	66.01	45.94	92.68	56.73	41.18
Gomti Nagar	42.12	27.52	35.76	79.51	66.09	47.71
Charbagh	29.78	43.90	46.40	106.74	75.78	56.07
Alambagh	32.15	44.07	47.68	108.78	48.20	46.56
Aminabad	39.21	42.25	41.49	77.65	90.87	40.13
Amausi	21.10	31.32	41.91	69.14	42.60	39.04
Average	**33.67**	**42.48**	**43.22**	**90.21**	**63.55**	**46.97**

ND= Not Done

 # Continuous Rainfall stated from midnight of 15th Nov and continued till 08:00 am.

Noise level

The noise levels were measured at 9 locations during Pre-Diwali, Post-Diwali and On-Diwali night to assess the impact of bursting of fire cracker and are tabulated in Table 2.

The noise levels were monitored between 07 – 12:30 PM for ~20 minutes at each location.

The highest noise level was recorded at Charbagh area with 84.3 dB(A) whereas the lowest was recorded at Chowk area with 71.6 dB(A) on Diwali night.

Firecrackers with noise level > 80 dB(A), may damage eardrum and reduce our hearing ability. High noise can may induce temporary or permanent hearing impairment.

Crackers may also trigger problems like annoyance, irritation, hypertension, stress, hearing loss, headache, sleep disturbance and respiratory problems such as allergic bronchitis, brochial asthma, sinusitis, rhinitis and laryngitis.

Table 2. Noise Level in dB(A) on Pre-Diwali, Diwali and Post-Diwali night

Locations	**Pre-Diwali** (November 13th, 2020)	**On-Diwali** (November 14th, 2020)
Charbagh (10:00-10:30 PM)	63.5	84.3
Chowk (11:00- 11:30 PM)	65.0	71.6
Aliganj (09:00- 30:00 PM	65.1	72.8
Vikas Nagar (07:00- 08:00 PM)	64.3	76.8
Indira Nagar (9:00-9:30 PM)	69.3	77.7
Aminabad (10:00-11:00 PM)	67.3	79.3
Gomti Nagar (08:30 -9:00 PM)	69.8	73.5
Amausi (10:30-11:00 PM)	61.6	72.2
Alambagh (11:30-12:00 PM)	66.6	81.8

CONCLUSION / FINDINGS

CSIR-IITR report proved that air quality became worse after the Diwali festival because of fireworks. This result implied that the Diwali festival leads to a small, but statistically significant increase in air pollution. The results of survey during Diwali festival clearly indicate significant deterioration of air quality in Lucknow city.

- The inhalable fine particulates (PM_{10} and $PM_{2.5}$) levels at most of the monitoring locations were found higher than the National Ambient Air Quality Standards (NAAQS).

On Diwali night, the level of PM_{10} had suddenly increased to 604.12 $\mu g/m^3$ i.e. increased by 164 % from 228.44 $\mu g/m^3$ over the pre-Diwali night and reduced to 205.04. $\mu g/m^3$ during post-Diwali night.

On Diwali night, the level of $PM_{2.5}$ had suddenly increased to 402.22 $\mu g/m^3$ i.e. increase by 282 % from 105.11 $\mu g/m^3$ over the pre-Diwali night and reduced to 100.95. $\mu g/m^3$ during post-Diwali night.

The highest noise level was recorded at Charbagh area with 84.3 dB(A) whereas the lowest was recorded at Chowk area with 71.6 dB(A) on Diwali night. The night time noise levels exceeded the prescribed CPCB night Standards at all locations.

The large quantity of pollutants formed due to burning of fire crackers during Diwali festival may be the cause of increase of air pollution in Lucknow city which may also be the cause of increased mortality and morbidity in urban area.Individual bursting of fire crackers should be discouraged. However, alternatively community celebration may be allowed at predefined areas.