
1. INTRODUCTION

Diwali is known as one of the most famous festival. On the occasion of this festival, people burn crackers and sparkles to express their happiness. The burning of these fireworks leads to metal pollution in air. Metal concentrations in ambient air have been observed to be very high as compared to background values on previous days. Influence of these celebrations on the immediate and long-term air quality and impact on the health and well being is a major area of concern. In 2016, it was discovered that on the next day of Diwali, PM_{2.5} levels in the air had crossed 700 µg/m³. These were highest levels recorded in the world and about 29 times above the standards as laid down by the World Health Organization (WHO)¹ as per National Ambient Air Quality Standards, 24 – hourly average for PM_{2.5} is 60 ug/m³ and PM₁₀ is 100 ug/m³. Broadly stated the presence of PM_{2.5} should range between 40 and 60 µg/m³ and the presence of PM₁₀ should range between 60 and 100 µg/m³. For the purpose of a lay person it would be enough to understand that air quality index or AQI is categorized as follows:

AQI Range	Category
0-50	Good
51-100	Satisfactory
101-200	Moderately Polluted
201-300	Poor
301-400	Very Poor
401-500	Severe

Keeping in view the harmful effects of firecrackers, Hon'ble Supreme Court of India directed that only remedy to stop its ill effects is to continue the suspension of licenses for the sale of fireworks in Delhi and in the NCR. According to an article published by the European Respiratory Society all fireworks contain carbon and sulfur, which are necessary for burning.² In addition, during fireworks manufacturing a range of substances are added such as arsenic, manganese, sodium oxalate, aluminum, iron dust powder, potassium perchlorate, strontium nitrate and barium nitrate, which act as stabilizers, oxidizers and added colors. The burning of fireworks releases a large amount of air pollutants, particularly sulfur dioxide (SO₂), carbon dioxide (CO₂), carbon monoxide (CO), and particulate matter (PM) along with several metal

salts, for example aluminum, manganese, and cadmium. Crackers and fireworks also cause a cumulative harm to health resulting from loud noise, air pollutants containing particulates and noxious gases, and also water pollution to some extent.



Courtesy: Economic Times e-paper, 11 October 2017

Even healthy people can experience health impacts from polluted air including respiratory irritation or breathing difficulties during exercise or outdoor activities.

High air pollution levels can cause immediate health problems including:

- Aggravated cardiovascular and respiratory illness
- Added stress to heart and lungs, which must work harder to supply the body with oxygen
- Damage cells in the respiratory system

Long-term exposure to polluted air can have permanent health effects such as:

- Accelerated aging of the lungs
- Loss of lung capacity and decreased lung function
- Development of diseases or rapid worsening such as asthma, bronchitis, emphysema, and possibly cancer
- Shortened life span

Those most susceptible to severe health problems from air pollution are:

- Individuals with heart disease, coronary artery disease or congestive heart failure

- Individuals with lung diseases such as asthma, emphysema or chronic obstructive pulmonary disease (COPD)
- Pregnant women
- Outdoor workers
- Older adults and the elderly
- Children under age 14
- Athletes who exercise vigorously outdoors

The crackers usually contain highly toxic heavy metals like cadmium and lead in addition to other metals like copper, manganese, zinc, sodium, magnesium and potassium in nitrate and nitrite forms. Both nitrates and nitrites and some metals are present. Both these radicals are oxidizing agents that are a ready source of oxygen in the process of combustion.

Magnesium content is usually high as compared to other metals like copper, manganese and zinc. Oxides of sulfur, phosphorous and nitrogen are very corrosive and highly acidic while carbon monoxide, one of the oxides of carbon is an extremely poisonous gas whose presence cannot be detected by our sensory system as it is odorless. Carbon monoxide combines with hemoglobin more than 200 times as readily as oxygen, so that low concentration levels have adverse health effects.

In a study conducted by Centre for Occupational and Environmental Health, Maulana Azad Medical College in the year 2008 – 09 to assess the health impact of Diwali Pollution on behalf of Delhi Pollution Control Committee following was observed. It revealed rise in the number ‘cerebrovascular accidents’, commonly known as ‘stroke’, during, and after Diwali. Reason to believe this is pollution levels may be contributing to this development. But the fact was that nearly 50 per cent were unaware of their Blood Pressure (B.P.) status. This coupled with consumption of sweets, and other fatty foods during the festival, may be related to these events due to a rise in blood pressure.³

Another 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). A detailed study of air pollution caused by firework display during lantern day festival in Beijing reported 57, 25 and 183% increase in SO₂, NO₂, and PM₁₀ 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 NO₃⁻, and 3% of SO₄²⁻ 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) In the present study, SO₂, NO₂, 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 SO₂, NO₂ and RSPM and SPM values were found in commercial and residential area to be 32.12, 60.26, 387.37 and 723.24 µg/m³ and in residential area to be 28.30, 52.69, 312.51, 618.31 µg/m³ respectively, which were very high when compared with any normal day of commercial area (7.18, 21.08, 126 and 257.21 µg/m³ respectively) and in residential area (6.28, 17.10, 107 and 214.67 µg/m³ respectively). On Diwali and after Diwali, the values of SO₂, NO₂ 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 complications.⁴

Harmful Health Effects

The harmful effects of ambient air pollutants are caused by the formation of reactive oxygen species, which in turn induce oxidative stress in the lungs resulting in a powerful cellular and mediator induced inflammatory response. When fireworks are set off, chemicals used in their composition react to ignite and propel the explosives with a resultant noticeable and odorous cloud of PM in the atmosphere. Inhalation of such particles is one of the most important routes of exposure to elevated concentrations of these emissions. PM deposition in the respiratory system mainly depends on the particle size. Several metallic elements of PM were found to be at substantially elevated levels in a number of studies during firework. The level of suspended particles in the air increases alarmingly during Diwali, causing eye, respiratory and hyper-sensitivity (allergic) problems. Although most people do not feel the immediate impact, these problems can develop later in life assuming serious proportions in susceptible populations.⁵

Around 30% to 40% increase in the cases of wheezing, respiratory diseases, exacerbation of bronchial asthma, and bronchitis patients of all ages and gender were reported during the Diwali festival.⁵

Nitrogen dioxide is less soluble and so penetrates to the smaller airways of the lungs where gas exchange occurs. The effect may be a serious impairment of the lining, i.e. alveolar and respiratory bronchiolar regions. This may affect the oxygen transfer during breathing giving rise to various disorders. In addition, respiratory allergies which may manifest as asthma may occur especially in children and the susceptible population.

High decibel levels may result in non auditory effects such as restlessness, anger, fidgetiness, impulsive behavior and over-reaction to situations. Children, pregnant women and those suffering from respiratory problems suffer the most due to excessive noise.

Diseases like Allergic bronchitis, acute exacerbation of bronchial asthma, Chronic bronchitis, Emphysema, COPD (Chronic Obstructive Pulmonary Diseases), Allergic rhinitis, Laryngitis, Sinusitis, Pneumonia and Common cold increase during this time.

Fireworks industry in India is an unorganized sector and is stigmatized for patronizing child labor. The industry is accused to negatively impact children two-folds, first by engaging them as workers in fireworks manufacturing, and second, by way of injuries that occur while children use the crackers. In the former case the working children while still in developing stage, have exposure to toxic and hazardous materials which may cause untold harm. In spite of wide publicity to educate them through advertisements and warnings, the preventable harm to children's health continues both in rural and urban areas.

Though fireworks-related eye injuries have been decreasing over the years, there is still a need to increase awareness about the dangers of fireworks. These injuries constitute an important cause of preventable blindness worldwide, and in India, such injuries are very common among children. Injuries to onlookers are also very common.

In addition to contributing to hearing loss, high noise levels can affect health in other ways too. There are immediate effects that may be temporary or may become longer lasting. Effects that may be longer lasting include insomnia, nervousness, bulimia, chronically high blood pressure, anxiety, depression and sexual dysfunction.

Effects of Chemicals Used in Firecrackers⁶:

- Lead: Affects the central nervous system in humans. When heated it can emit highly toxic fumes. Young children can suffer mental retardation and semi-permanent brain damage by exposure to lead.
- Magnesium: Inhalation of magnesium dust and fumes can cause metal fume fever. Particles embedded in the skin produce gaseous blebs and gas gangrene. Dangerous fire hazard in the form of dust or flakes when exposed to flames. Poisoning takes the form of progressive deterioration in the central nervous system.
- Zinc: Pure zinc powder is non-toxic to humans by inhalation but difficulty arises from oxidation (burning), as it emits zinc fumes. It stimulates the sensation of vomiting.
- Manganese: Toxicity caused by dust or fumes. The main symptoms of exposure are languor, sleepiness, weakness, emotional disturbances, spastic gait and paralysis.
- Sodium: When heated in air, it emits toxic fumes of sodium oxide. Can cause dangerous fire hazard when exposed to heat and moisture.
- Potassium: Dangerous fire hazard and explosion can occur.
- Copper: Inhalation of copper dust and fume causes irritation in the respiratory tract. Absorption of excess copper results in "Wilson's disease" in which excess copper is deposited in the brain, skin, liver, pancreas and the myocardium (middle muscular layer in the heart).
- Cadmium: Its absorption can damage the kidneys and can cause anaemia. Cadmium causes increased blood pressure and also a disease called "Itai-Itai", which makes bones brittle resulting in multiple fractures.
- Phosphorous in the form of PO₄: Dangerous fire hazard when exposed to heat or chemical reaction. Poison by inhalation, ingestion, skin contact and subcutaneous routes. Ingestion affects the central nervous system. Toxic quantities have an acute effect on the liver and can cause severe eye damage.
- Sulphur in the form of SO₄ : It affects the upper respiratory tract and the bronchi. It may cause edema of the lungs or glottis, and can produce respiratory paralysis. Poison to humans by inhalation. An eye, skin and mucous membrane irritant and corrosive.
- Nitrate: Highly inflammable and on decomposition they emit highly toxic fumes. The symptoms are dizziness, abdominal cramps, vomiting, bloody diarrhea, weakness, convulsions and collapse.
- Nitrite: Large amounts taken by mouth may produce nausea, vomiting, cyanosis, collapse and coma. Repeated small doses can cause a fall in blood pressure, rapid pulse, headaches and visual disturbances. When heated, emit highly toxic fumes of NO_x.

2. METHODOLOGY

Study was awarded to Centre for Occupational and Environmental Health located in Maulana Azad Medical College because of its distinguished status in the field of Occupational and Environmental Health. This kind of studies requires careful selection of variables and ought to be specific and sensitive. The study was conducted during Dusshera and Diwali festival. 4 (Four) areas of Delhi were identified in consultation with Central Pollution Control Board. Areas were Pitampura, Kotla, Sirifort, Parivesh Bhawan. The families in these areas were interviewed by means of a specifically designed questionnaire taking into account the respiratory, skin, ear, eye and other relevant symptoms. Study was conducted in two phases i.e. two days before (27 – 29 September, 2017) and after (1 and 2 October, 2017) Dusshera festival and second phase for Diwali festival that lasted for 6 days viz., 3 days before Diwali (16 – 18 October, 2017) and 3 days after Diwali (20 – 22 December, 2017) to identify the acute skin, eye, respiratory and ear problems. A team was constituted to interview the subjects. The interview questionnaire were pre – tested and validated (Annexure I, II, III, IV). Each team included a physician, a spirometry technician and a trained volunteer for questionnaire filling. Around 223 subjects had also undergone through portable spirometry to assess their lung functions.



The eye injury and burn data were obtained from different hospitals in the vicinity of the identified areas during Dusshera and Diwali. Estimation of eight heavy metals viz., Arsenic, mercury, lead, strontium, antimony, barium, potassium and sulfur in urine of 40 subjects (10 from each district) chosen randomly was done by Bhagawathi Ana Labs, Hyderabad by using

Method No.B.01 by ICPMS/ICP OES. Simultaneously, a specially designed questionnaire were sent to selected hospitals and clinics to identify the cases with respiratory illnesses, Eye, Ear, Skin ailments and other chronic diseases like stroke, heart disease etc. seen in OPD as well as emergency during both pre and post Dusshera and Diwali for the year 2016 and 2017. Ambient air as well as noise monitoring was conducted by Central Pollution Control Board (Annexure IX).

A statistician was involved to analyze the collected data

Around 470 subjects were interviewed for Dusshera and around 787 subjects for Diwali in these areas.

Data on injuries and serious medical conditions leading to hospital admission was obtained from different hospitals in the vicinity of the identified areas. The hospitals were provided with a specifically designed format (Annexure V). Data on acute cerebral and cardiac events, respiratory disorders, skin and eye burns among children, adolescents and adults was collected. The data was gathered for three days prior to Dusshera and Diwali and three after Dusshera and Diwali for two years i.e. 2016 and 2017. In total, format was forwarded to 54 hospitals, however only 20 hospitals and health care organizations completed the format and responded.

2.1 Sample size

Around 470 subjects for Dusshera festival and around 787 subjects for Diwali festival were interviewed of different age groups. Every fourth house was chosen for interview and with Pulmonary Function Testing on random basis (50 in each area, 3 days before and after Diwali) on the subjects who do not have any respiratory problem. Data was collected from -- hospitals for admissions attributable to acute cardiac and cerebral events (cerebro – vascular accidents and heart attacks), respiratory disorders (asthma, and exacerbation of disorders such as chronic obstructive pulmonary disease) and skin or eye burns.

2.2 Tools of study

A semi-structured questionnaire was developed and was used to collect information. A team of surveyors was identified for collecting the required information using newly developed and pre - tested interview questionnaire. The surveyors were trained to exclude bias while interviewing and to record the information correctly. The collected data was coded and entered in Microsoft Excel Spreadsheet and analyzed by software Statistical Package for the Social Science (SPSS) (Ver. 20).

Study area:- The residents of four different districts in Delhi were identified in consultation with Central Pollution Control Board. Health care institutions were approached to participate in the exercise to help create an overall profile of the adverse impact, if any. The plan was to identify any association with increased level of air and noise pollution that the bursting of crackers and burning of firecrackers during festivals.

Residential areas: Selected Areas were:

- Pitampura
- Kotla
- Parivesh Bhawan
- Sirifort



Health care institutions: The hospitals and health care institutions who participated in the study include:

1. All India Institute of Medical Sciences
2. Dr. B.R Sur Homeopathic Medical College and Research Institute
3. Deep Chand Bhandu Hospital
4. Delhi Heart and Lung Institute
5. ESI Hospital, Basaidharapur
6. G.B. Pant Hospital
7. Hindu Rao Hospital
8. Jaipur Golden Hospital
9. Lady Hardinge
10. Lok Nayak Hospital
11. Max Hospital, Patparganj
12. Max Hospital, Saket
13. MGS Hospital
14. Primus Hospital
15. Pushpawati Singhaniya
16. Sardar Vallabh Bhai Patel Hospital
17. Shanti Mukund Hospital
18. Sri Balaji Action Medical Institute
19. Sunder Lal Jain Hospital
20. Tirath Ram Hospital

3. OBSERVATIONS & RESULTS

The survey was performed in 4 different residential areas of Delhi viz. Kotla, Parivesh Bhawan, Siri Fort and Pitampura. The survey was done pre- & post- Dussehra and pre- and post- Diwali. All the participants were interviewed using a pre-designed questionnaire format.

I. Dussehra:

A survey was conducted in same subjects, 462 and 460 residents pre- and post- Dussehra respectively from the 4 residential areas. The number of participants interviewed in different residential areas is shown in Table 1.

Table 1: Details of residents interviewed during pre- and post-Dussehra

Residential Area	No. of participants	
	Pre-Dussehra	Post-Dussehra
Kotla	120	120
Parivesh Bhawan	134	132
Siri Fort	110	110
Pitampura	108	108
Total	462	460

a) Age of participants

The youngest participants were of Parivesh Bhawan, mean \pm SD being 30.72 \pm 15.85 years and the oldest participants were of Pitampura, mean \pm SD being 41.93 \pm 19.08 years (Table 2).

b) Sex of participants

The male: female ratio was approximately 1: 1. The maximum percentage of male interviewed was 54.5% in Siri Fort while the maximum percentage of female interviewed was 48.5% in Parivesh Bhawan (Table 2).

c) Addiction status

Smoking, alcohol drinking and tobacco chewing was reported maximum from Siri Fort (11.8%, 12.7% & 11.8%, respectively) (Table 2).

Table 2: Demographic profile of Dussehra survey of 4 residential areas of Delhi

Demographic details	Kotla (N=120)	Parivesh Bhawan (N=134)	Siri Fort (N=110)	Pitampura (N=108)
Age (years) (mean±SD)	37.37 ± 16.99	30.72 ± 15.85	31.99 ± 15.67	41.93 ± 19.08
Sex				
Male	63 (52.5%)	69 (51.5%)	60 (54.5%)	57 (52.8%)
Female	57 (47.5%)	65 (48.5%)	50 (45.5%)	51 (47.2%)
Smoking	6 (5.0%)	7 (5.2%)	13 (11.8%)	5 (4.6%)
<10 years	4/6 (66.7%)	4/7 (57.1%)	4/13 (30.8%)	2/5 (40.0%)
≥10 years	2/6 (33.3%)	3/7 (42.9%)	9/13 (69.2%)	3/5 (60.0%)
Alcohol	13 (10.8%)	12 (8.9%)	14 (12.7%)	13 (12.0%)
<10 years	12/13 (92.3%)	8/12 (66.7%)	4/14 (28.6%)	5/13 (38.5%)
≥10 years	1/13 (7.7%)	4/12 (33.3%)	10/14 (71.4%)	8/13 (61.5%)
Tobacco	9 (7.5%)	5 (6.7%)	13 (11.8%)	3 (2.8%)
<10 years	8/9 (88.9%)	3/5 (60.0%)	7/13 (53.8%)	1/3 (33.3%)
≥10 years	1/9 (11.1%)	2/5 (40.0%)	6/13 (46.2%)	2/3 (66.7%)

d) Complaints of participant pre-Dussehra:

The maximum complaints reported are as follows, 9.3% participants of Pitampura complained about sputum, 5.4% complained about chest pain in Siri Fort, 25% of Kotla participants reported weakness and 14.2% had prolonged illness (Table 3). The distribution of complaints reported area-wise and in survey population is shown in Figure 1.

Table 3: Complaints of pre-Dussehra survey of 4 residential areas of Delhi

Parameters	Kotla (N=120)	Parivesh Bhawan (N=134)	Siri Fort (N=110)	Pitampura (N=108)
Sputum	6 (5.0%)	11 (8.2%)	6 (5.4%)	10 (9.3%)
Chest pain	5 (4.2%)	6 (4.5%)	6 (5.4%)	3 (2.8%)
Weakness	30 (25.0%)	10 (7.5%)	8 (7.3%)	13 (12.0%)
Prolonged illness	17 (14.2%)	7 (5.2%)	6 (5.4%)	15 (13.9%)
Treatment	21 (17.5%)	11 (8.2%)	8 (7.3%)	32 (29.6%)

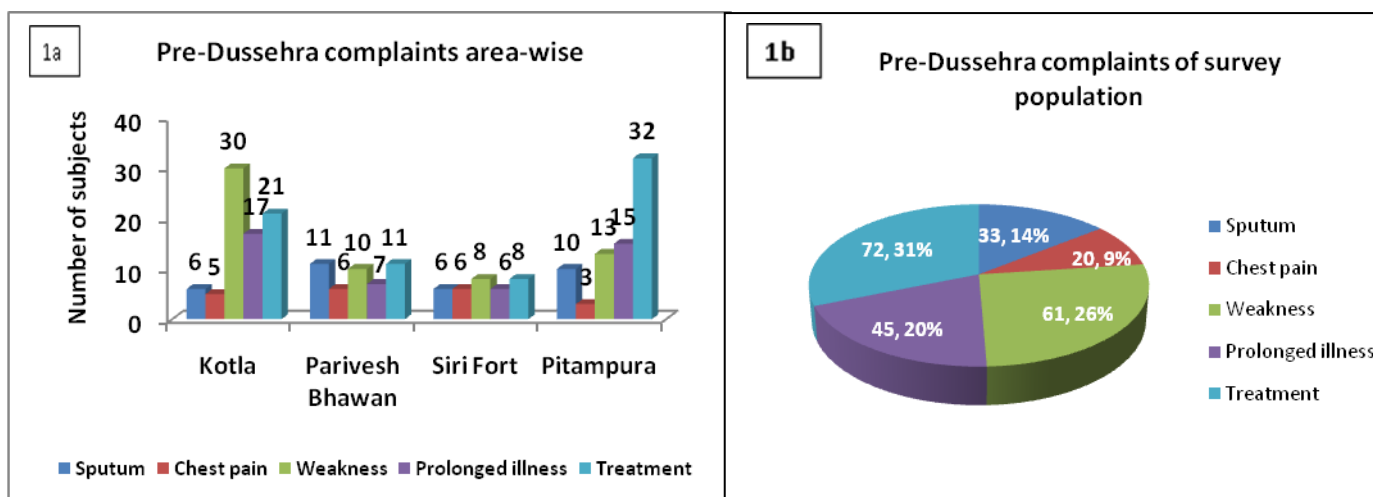


Figure 1: Pre-Dussehra complaints area-wise and in survey population

e) Complaints of participant post-Dussehra:

The maximum complaints reported are as follows, 3.7% participants of Pitampura complained about abnormal breathing, 3.7% had fever in Siri Fort, 90.9% of Parivesh Bhawan participants reported noisy environment and 4.5% had eye problem in Siri Fort area (Table 4). The distribution of complaints reported by survey population is shown in Figure 2.

Table 4: Post Dussehra complaint details of 4 residential areas of Delhi

Symptoms	Kotla (N=120)	Parivesh Bhawan (N=132)	Siri Fort (N=110)	Pitampura (N=108)
Abnormal Breathing	3 (2.5%)	3 (2.3%)	4 (3.6%)	4 (3.7%)
Whistling	1 (0.8%)	0 (0%)	0 (0%)	0 (0%)
Fever	2 (1.7%)	1 (0.8%)	3 (2.7%)	0 (0%)
Fatigue	0 (0%)	1 (0.8%)	2 (1.8%)	1 (0.9%)
Lack in Concentration	0 (0%)	2 (1.5%)	0 (0%)	0 (0%)
Environment noisy	1 (0.8%)	120 (90.9%)	2 (1.8%)	0 (0%)
Did it affect your hearing	1 (0.8%)	1 (0.8%)	0 (0%)	0 (0%)
Earlier hearing disease	0 (0%)	1 (0.8%)	0 (0%)	0 (0%)
Eye Problems	1 (0.8%)	2 (1.5%)	5 (4.5%)	0 (0%)

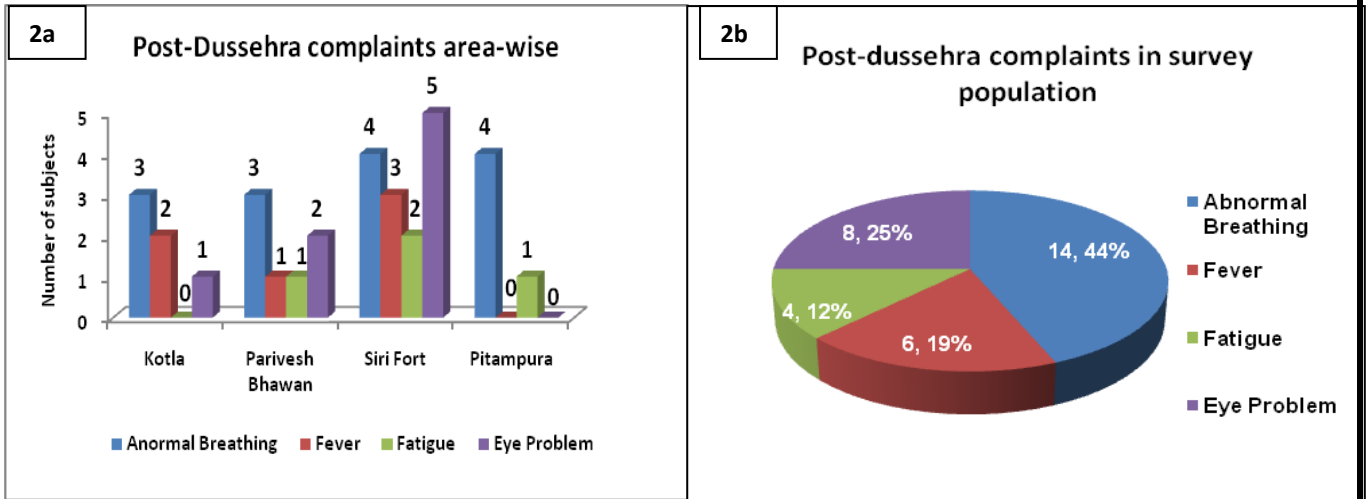


Figure 2: Post-Dussehra complaints area-wise and in survey population

f) Comparison of respiratory disease between pre- and post-dussehra

No difference was observed in complaints of cough and breathlessness between pre- and post-Dussehra in Kotla and Siri Fort ($p > 0.05$). However post-Dussehra in Parivesh Bhawan, there was significant decrease in cough (17.2% vs 8.3%), though presence of phlegm was higher post-Dussehra ($p = 0.0003$). In Pitampura the complaint of breathlessness and phlegm in cough decreased post-Dussehra ($p = 0.04$) (Table 5 & Figure 3). However, over all there is marginal increase in these complaints. This can be due to poor ambient air. However, it cannot be concluded that bursting of crackers is the sole factor.

Table 5: Comparison of respiratory disease pre- and post-Dussehra area-wise

Symptoms	Pre-Dussehra	Post-Dussehra	p-value
Kotla	N=120	N=120	
Cough	3 (2.5%)	4 (3.3%)	1.00
Breathlessness	5 (4.2%)	2 (1.7%)	0.45
Cough with Phlegm	2/3	2/4	1.00
Parivesh Bhawan	N=134	N=132	
Cough	23 (17.2%)	11 (8.3%)	0.04*
Breathlessness	6 (4.5%)	1 (0.8%)	0.12
Cough with Phlegm	2/23	8/11	0.0003*
Siri Fort	N=110	N=110	
Cough	18 (16.4%)	10 (9.1%)	0.16
Breathlessness	8 (7.3%)	3 (2.7%)	0.21
Cough with Phlegm	8/18	4/10	1.00
Pitampura	N=108	N=108	
Cough	13 (12.0%)	6 (5.6%)	0.15
Breathlessness	8 (7.4%)	1 (0.9%)	0.04*
Cough with Phlegm	10/13	1/6	0.04*

*p-value significant

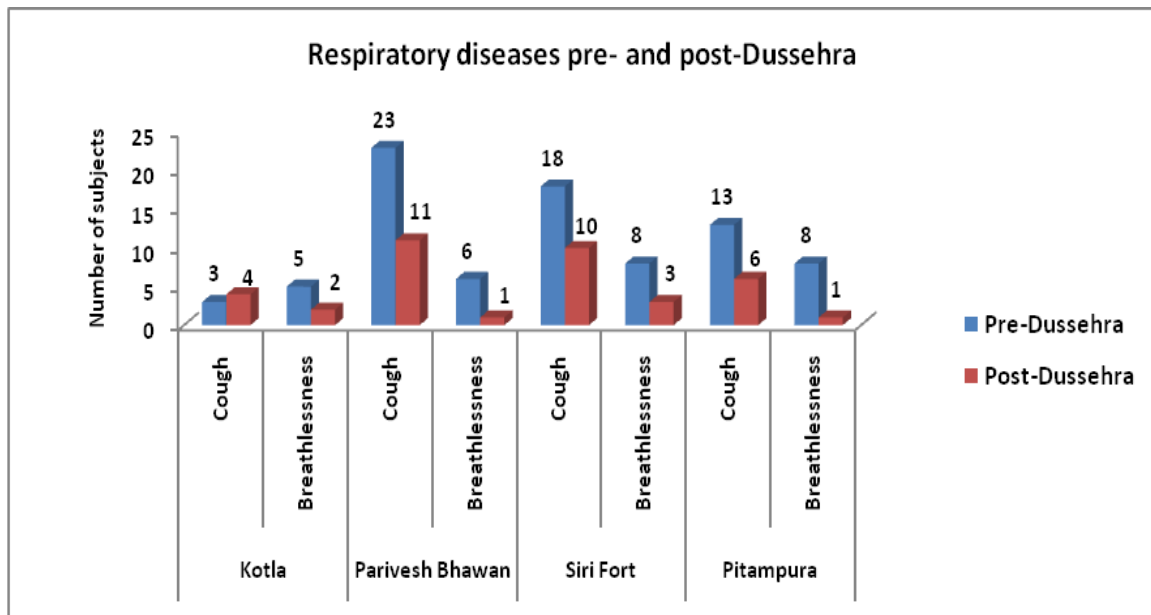


Figure 3: Respiratory disease pre- and post-Dussehra area-wise

g) Hospital admission pre- and post-Dussehra:

The data of admission pre- and post-Dussehra was collected from 20 hospitals of Delhi in a prescribed format. The details of hospital admission pre- and post-Dussehra are shown in Table 6 and the details of hospital admission pre- and post-Dussehra due to cardiac problems, stroke, respiratory problems and burns are shown in Table 7.

Table 6: Details of hospital showing pre- and post-Dussehra admissions

S.No.	Hospitals	Admission	
		Pre-Dussehra	Post-Dussehra
1.	All India Institute of Medical Sciences	3648	302
2.	Dr. B.R Sur Homeopathic Medical College and Research Institute	34	12
3.	Deep Chand Bhandu Hospital	186	288
4.	Delhi Heart and Lung Institute	155	63
5.	ESI Hospital, Basaidharapur	380	413
6.	G.B. Pant Hospital	67	53
7.	Hindu Rao Hospital	239	256
8.	Jaipur Golden Hospital	18	7
9.	Lady Hardinge	14	6
10.	Lok Nayak Hospital	115	117
11.	Max Hospital, Patparganj	330	155
12.	Max Hospital, Saket	18	19
13.	MGS Hospital	4	2
14.	Primus Hospital	23	15
15.	Pushpawati Singhaniya	3	0
16.	Sardar Vallabh Bhai Patel Hospital	48	96
17.	Shanti Mukund Hospital	1	5
18.	Sri Balaji Action Medical Institute	282	134
19.	Sunder Lal Jain Hospital	10	18
20.	Tirath Ram Hospital	2	1
	Total	5577	1962

Table 7: Details of reasons for hospital admissions pre- and post-Dussehra

S.No.	Hospitals	Admissions			
		Cardiac Problems	Stroke	Respiratory Problems	Burns
		Pre-/Post-Dussehra	Pre-/Post-Dussehra	Pre-/Post-Dussehra	Pre-/Post-Dussehra
1.	All India Institute of Medical Sciences	2445/8	803/294	400/0	0/0
2.	Dr. B.R Sur Homeopathic Medical College and Research Institute	0/0	0/0	19/9	0/0
3.	Deep Chand Bhandu Hospital	78/128	3/3	105/157	0/0
4.	Delhi Heart and Lung Institute	110/41	0/0	45/22	0/0
5.	ESI Hospital, Basaidharapur	169/179	0/0	211/234	0/0
6.	G.B. Pant Hospital	65/51	2/2	0/0	0/0
7.	Hindu Rao Hospital	93/83	65/86	81/87	0/0
8.	Jaipur Golden Hospital	6/1	2/3	10/6	0/0
9.	Lady Hardinge	2/1	0/0	12/5	0/0
10.	Lok Nayak Hospital	42/49	10/5	59/63	4/0
11.	Max Hospital, Patparganj	100/56	149/56	81/43	0/0
12.	Max Hospital, Saket	2/1	2/1	14/17	0/0
13.	MGS Hospital	28/1	2/1	14/17	0/0
14.	Primus Hospital	3/6	1/0	19/9	0/0
15.	Pushpawati Singhaniya	0/0	0/0	3/0	0/0
16.	Sardar Vallabh Bhai Patel Hospital	15/35	0/0	33/61	0/0
17.	Shanti Mukund Hospital	0/0	0/0	1/5	0/0
18.	Sri Balaji Action Medical Institute	72/45	137/49	73/40	0/0
19.	Sunder Lal Jain Hospital	2/5	2/3	6/10	0/0
20.	Tirath Ram Hospital	1/0	1/0	0/1	0/0
	Total	3205/689	1177/499	1191/774	4/0

There was an increase in hospital admission post-dussehra in 8 (40%) hospitals (Table 8 & Figure 4). The highest and lowest number of hospital admission was seen in Deep Chand Bhandu Hospital (288 patients) and Shanti Mukund Hospital (5 patients), respectively. However, around 12 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke.

Table 8: Detail of hospitals showing increased admission post-Dussehra

Hospitals	Admission	
	Pre-Dussehra	Post-Dussehra
LNJP Hospital	115	117
Sardar VB Patel Hospital	48	96
Hindu Rao Hospital	239	256
Sunder Lal Jain Hospital	10	18
Deep Chand Bandhu Hospital	186	288
ESI, Basaidharpur	380	413
Shanti Mukund Hospital	1	5
Max Hospital Saket	18	19

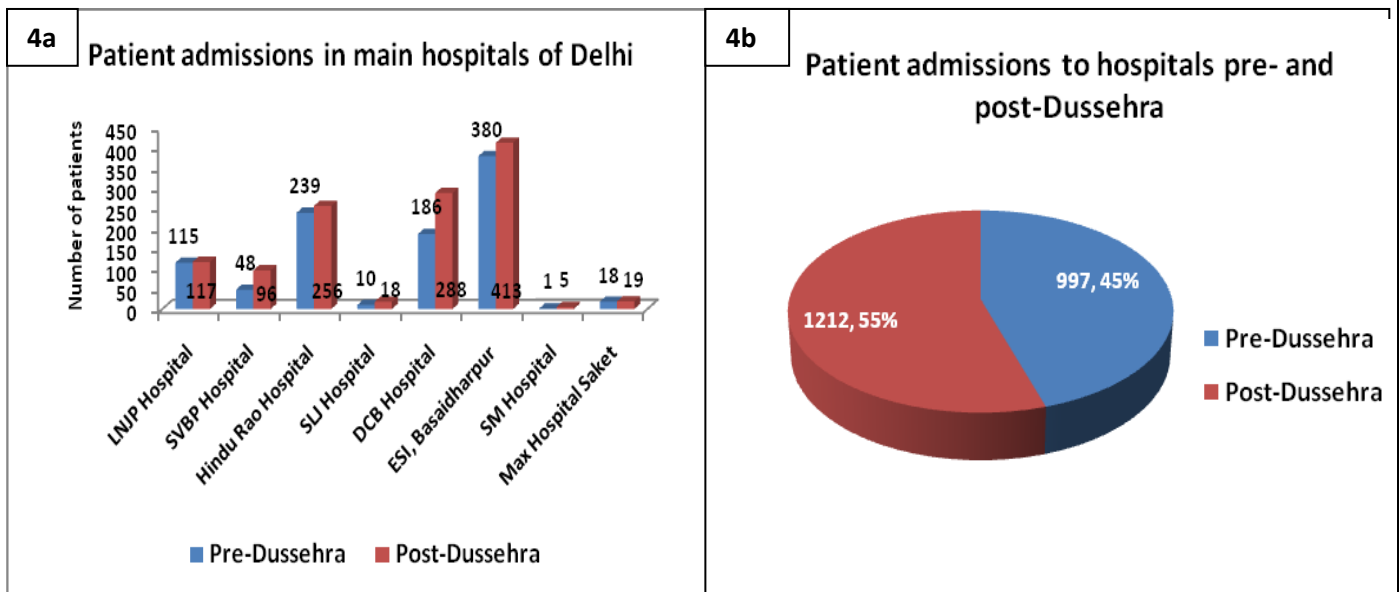


Figure 4: Patient admissions to hospitals of Delhi pre- and post-Dussehra

There was significant increase in hospital admission in Deep Chand Bandhu Hospital post-Dussehra.

h) Cardiac Problem

There was an increase in hospital admission due to cardiac problem post-dussehra in 6 (30%) hospitals (Table 9 & Figure 5).

The highest and lowest number of hospital admission was seen in ESI, Basaidharpur (179 patients) and Sunder Lal Jain Hospital (5 patients), respectively. However, around 14 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke. The Deep Chand Bandhu Hospital showed significant increase in cardiac problems post-Dussehra as compared to other hospitals.

Table 9: Hospital showing increased admission due to cardiac problems

Hospitals	Cardiac Problems problems	
	Pre-Dussehra	Post-Dussehra
LNJP Hospital	42	49
Sardar Vallabh Bhai Patel	15	35
Sunder Lal Jain Hospital	2	5
Deep Chand Bhandu Hospital	78	128
ESI, Basaidharpur	169	179
Primus Hospital	3	6

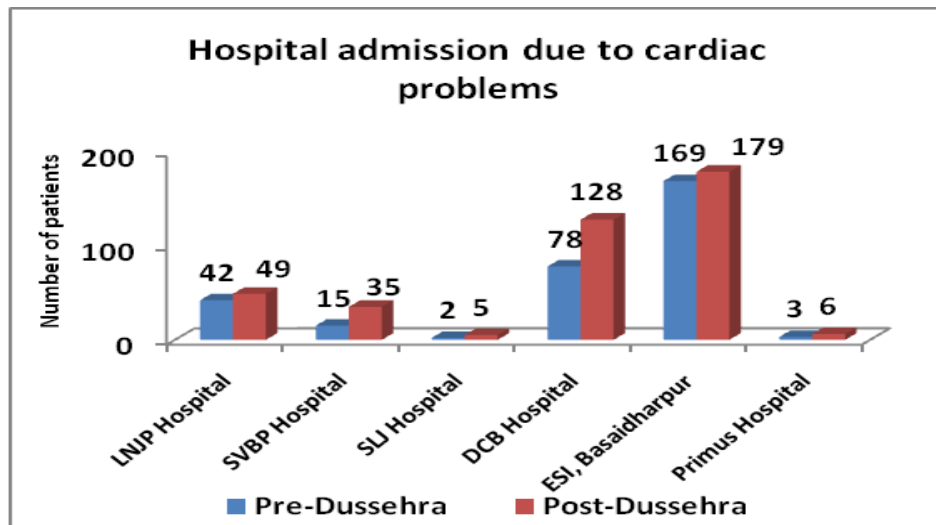


Figure 5: Hospital admission due to cardiac problems pre- and post-dussehra

i) Stroke

There was an increase in hospital admission due to stroke post-dussehra in 2 (10%) hospitals (Table 10 & Figure 6). The highest and lowest number of hospital admission was seen in Hindu Rao Hospital (86 patients) and Sunder Lal Jain Hospital (3 patients), respectively. However, around 10 – 12 hospitals did not show any increase in hospital admissions/visits for

respiratory, cardiac and stroke. The Hindu Rao Hospital showed significant increase in stroke post-Dussehra as compared to other hospital.

Table 10: Hospital showing increased admission due to stroke¹

Hospitals	Stroke	
	Pre-Dussehra	Post-Dussehra
Hindu Rao Hospital	65	86
Sunder Lal Jain Hospital	2	3

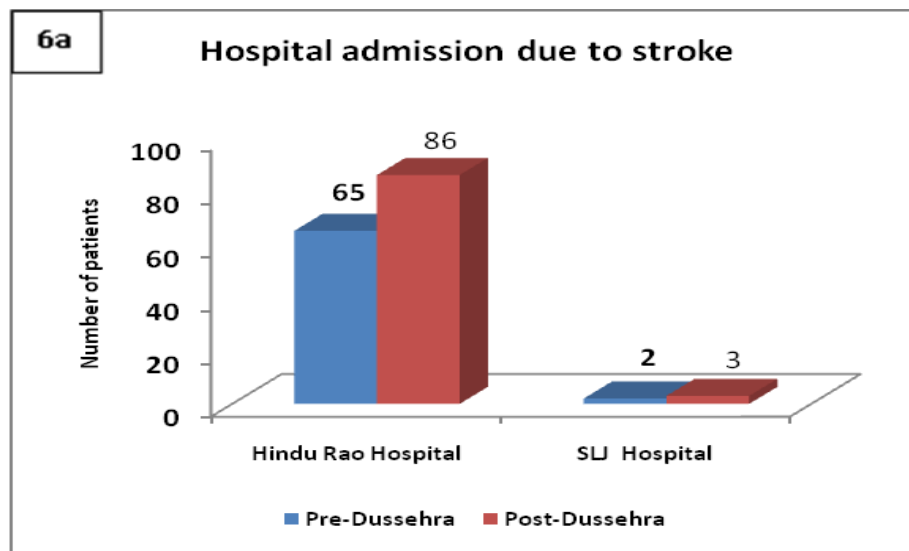


Figure 6: Hospital admission due to stroke pre- and post- Dussehra

j) Respiratory problems

There was increase in hospital admission due to respiratory problems post-dussehra in 9 (45%) hospitals (Table 11 & Figure 7). The highest and lowest number of hospital admission was seen in ESI, Basaidharpur (234 patients) and Tirathram Hospital (1 patient), respectively. However, around 11 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke. The Deep Chand Bhandu Hospital showed significant increase in respiratory problems post-Dussehra as compared to other hospitals.

¹ Other hospitals did show/share any increase in admission

Table 11: Hospital showing increased admission due to respiratory problems

Hospitals	Respiratory problems	
	Pre-Dussehra	Post-Dussehra
LNJP Hospital	59	63
Sardar VB Patel Hospital	33	61
Hindu Rao Hospital	81	87
Sunder Lal Jain Hospital	6	10
Shanti Mukund Hospital	6	10
Deep Chand Bhandu Hospital	105	157
ESI, Basaidharpur	211	234
Max Hospital, Saket	14	17
Tirathram Hospital	0	1

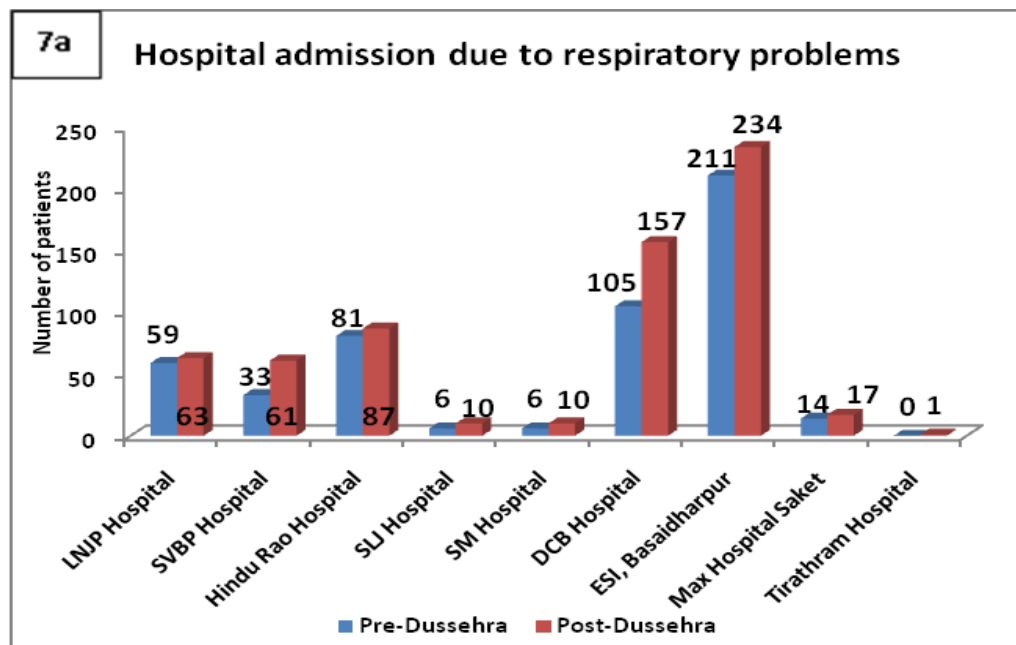


Figure 7: Hospital admission due to respiratory problems pre- and post-Dussehra

II. Diwali:

A survey was conducted in same subjects, 788 and 787 residents pre- and post- Diwali respectively from the 4 residential areas. The number of participants interviewed in different residential areas is shown in Table 12.

Table 12: Details of residents interviewed during pre- and post-Diwali

Residential Area	No. of participants	
	Pre-Diwali	Post-Diwali
Kotla	194	194
Parivesh Bhawan	201	201
Siri Fort	194	194
Pitampura	199	198
Total	788	787

a) Age of participants

The youngest participants were of Parivesh Bhawan, mean \pm SD being 36.53 \pm 17.46 years and the oldest participants were of Pitampura, mean \pm SD being 46.30 \pm 14.87 years (Table 13).

b) Sex of participants

The maximum percentage of male interviewed was 62.9% in Siri Fort while the maximum percentage of female interviewed was 47.8% in Parivesh Bhawan (Table 13).

c) Addiction status

Smoking, and tobacco chewing was reported maximum from Siri Fort (16.5% each). Alcohol drinking (22.2%) was reported maximum from Kotla (Table 13).

Table 13: Demographic profile of Diwali survey of 4 residential areas of Delhi

Demographic profile	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=199)
Age	38.74 ± 19.17	36.53 ± 17.46	40.67 ± 15.89	46.30 ± 14.87
Sex				
Male	120	105 (52.2%)	122	120 (60.3%)
Female	(61.9%) 74 (38.1)	96 (47.8%)	(62.9%) 72 (37.1%)	79 (39.7%)
Smoking	31 (16.0%)	16 (8.0%)	32 (16.5%)	22 (11.1%)
Alcohol	43 (22.2%)	18 (8.9%)	38 (19.6%)	32 (16.1%)
Tobacco	28 (14.4%)	30 (14.9%)	32 (16.5%)	31 (15.6%)
≥10 hours of Outdoor	83 (42.8%)	92 (45.8%)	74 (37.1%)	96 (48.2%)

d) Complaints of participant pre-Diwali:

The maximum complaints reported are as follows, 24.7% and 26.8% participants of Kotla complained about sputum and prolonged illness respectively, 24.4% & 44.3% complained about chest pain & weakness respectively from Parivesh Bhawan, 25% of Kotla participants reported weakness and 14.2% had prolonged illness (Table 14). The distribution of complaints reported by survey population is shown in Figure 8.

Table 14: Pre-Diwali complaints of 4 residential areas of Delhi

Complaints	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=199)
Sputum	48 (24.7%)	32 (15.9%)	5 (2.6%)	42 (21.1%)
Chest pain	45 (23.2%)	49 (24.4%)	9 (4.6%)	18 (9.0%)
Weakness	83 (42.8%)	89 (44.3%)	11 (5.7%)	75 (37.7%)
Prolonged illness	52 (26.8%)	23 (11.4%)	43 (22.2%)	51 (25.6%)
Treatment History	57 (29.4%)	50 (24.9%)	29 (14.9%)	55 (27.6%)

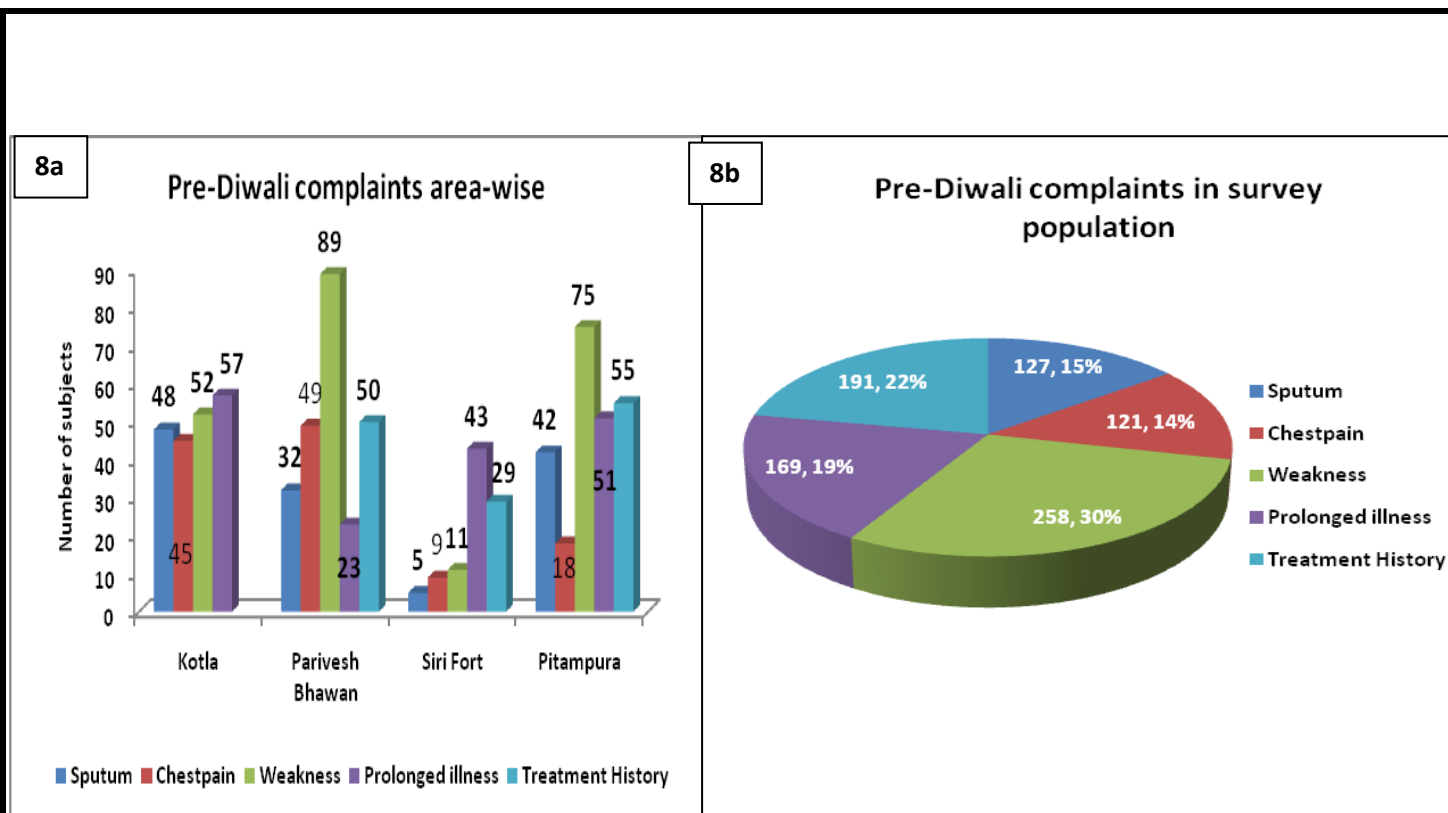


Figure 8: Pre-Diwali complaints area-wise and in survey population

The clinical findings, abnormal pulse rate (18.6%) and abnormal blood pressure (34.7%) were highest in Pitampura, abnormal respiratory rate (5.7%), icterus (33%), cyanosis (12.4%), clubbing (10.3%) were found in Siri Fort. The presence of pallor (30.8%) was highest in Parivesh Bhawan (Table 15). The distribution of complaints reported by survey population is shown in Figure 9.

Table 15: Pre-Diwali clinical findings of 4 residential areas of Delhi

Clinical findings	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=199)
Abnormal Pulse rate	23 (11.8%)	23 (11.4%)	8 (4.1%)	37 (18.6%)
Abnormal Blood Pressure	0 (0%)	46 (22.9%)	49 (25.3%)	69 (34.7%)
Abnormal Respiratory rate	3 (1.5%)	2 (1.0%)	11 (5.7%)	7 (3.5%)
Pallor	27 (13.9%)	62 (30.8%)	32 (16.5%)	1 (0.5%)
Icterus	8 (4.1%)	7 (3.5%)	64 (33.0%)	7 (3.5%)
Cynosis	2 (1.0%)	0 (0.0%)	24 (12.4%)	2 (1.0%)
Clubbing	6 (3.1%)	2 (1.0%)	20 (10.3%)	3 (1.5%)
Pedal Edema	12 (6.2%)	7 (3.5%)	12 (6.2%)	8 (4.0%)
Lymphadenopathy	5 (2.6%)	0 (0%)	4 (2.1%)	1 (0.5%)
Abnormal Chest Findings	2 (1.0%)	12 (6.0%)	1 (0.5%)	26 (13.1%)
Abnormal CVS	10 (5.2%)	6 (3.0%)	0 (0%)	10 (5.0%)

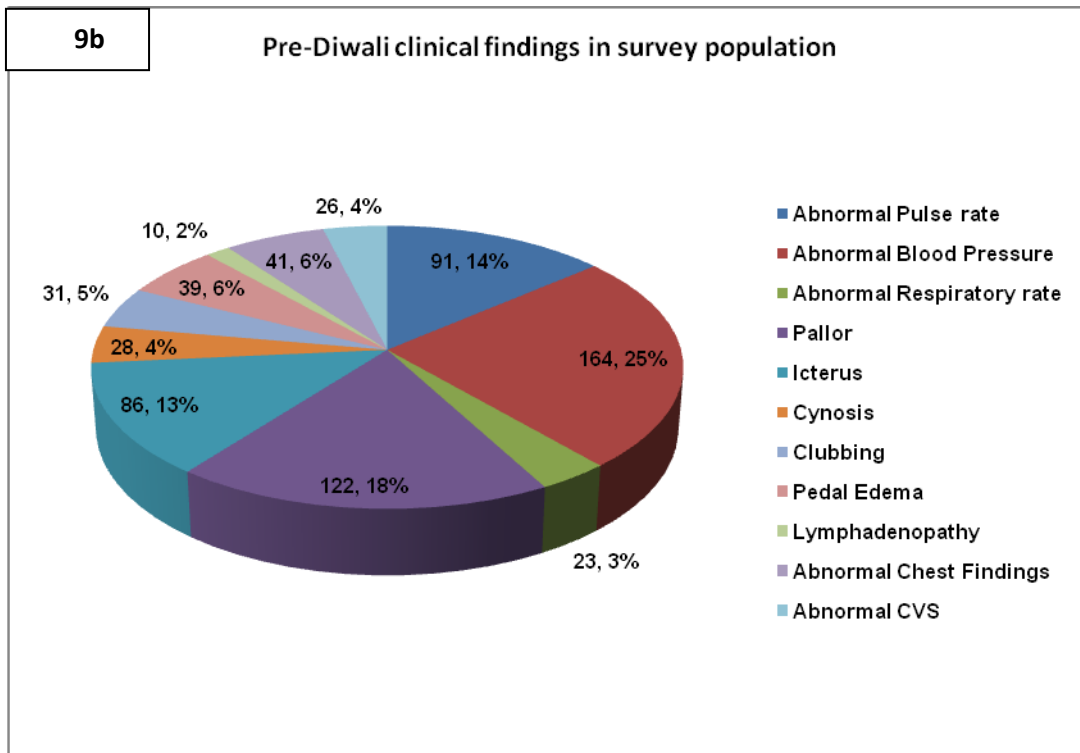
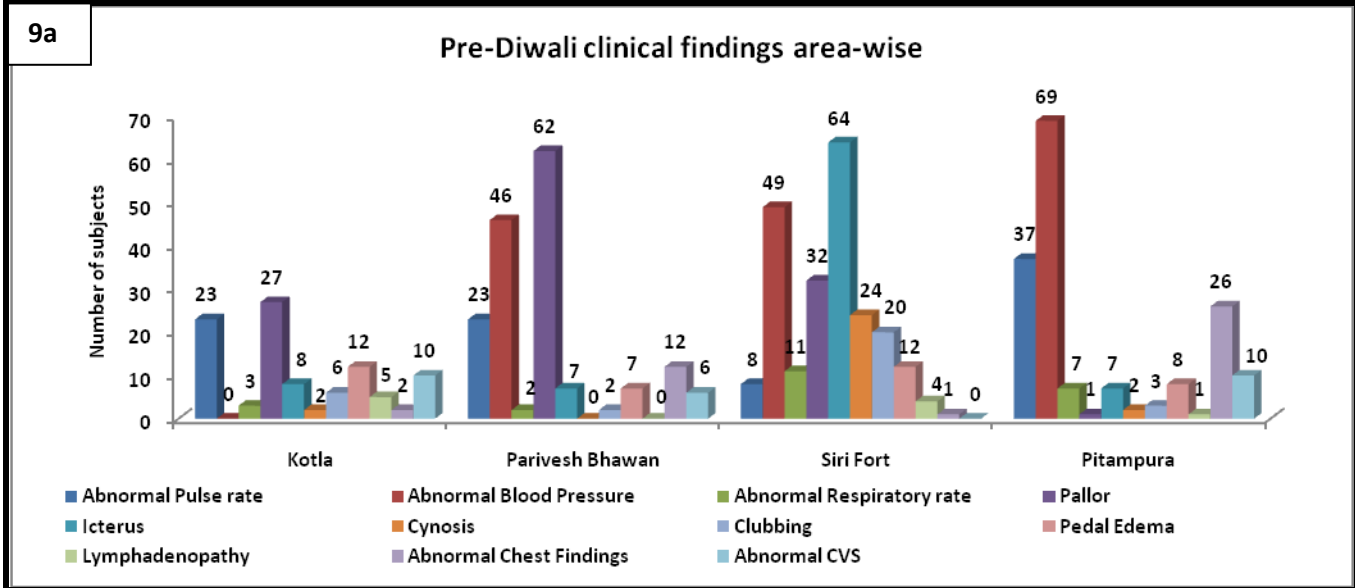


Figure 9: Pre-Diwali clinical findings area-wise and in in survey population

e) Complaints of participant post-Diwali:

i. General Complaints

The maximum complaints reported are as follows, 27.3% participants of Pitampura complained about abnormal breathing, 6.7% and 37.1% reported fever and fatigue respectively in Kotla (Table 16). The distribution of complaints reported by survey population is shown in Figure 10.

Table 16: Post-Diwali complaints of 4 residential areas of Delhi

Complaints	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Abnormal Breathing	41 (21.1%)	17 (8.5%)	21 (10.8%)	54 (27.3%)
Whistling	0 (0%)	0 (0%)	0 (0%)	1 (0.5%)
Fever	13 (6.7%)	6 (3.0%)	4 (2.1%)	1 (0.5%)
Fatigue	72 (37.1%)	2 (1.0%)	0 (0%)	11 (5.6%)

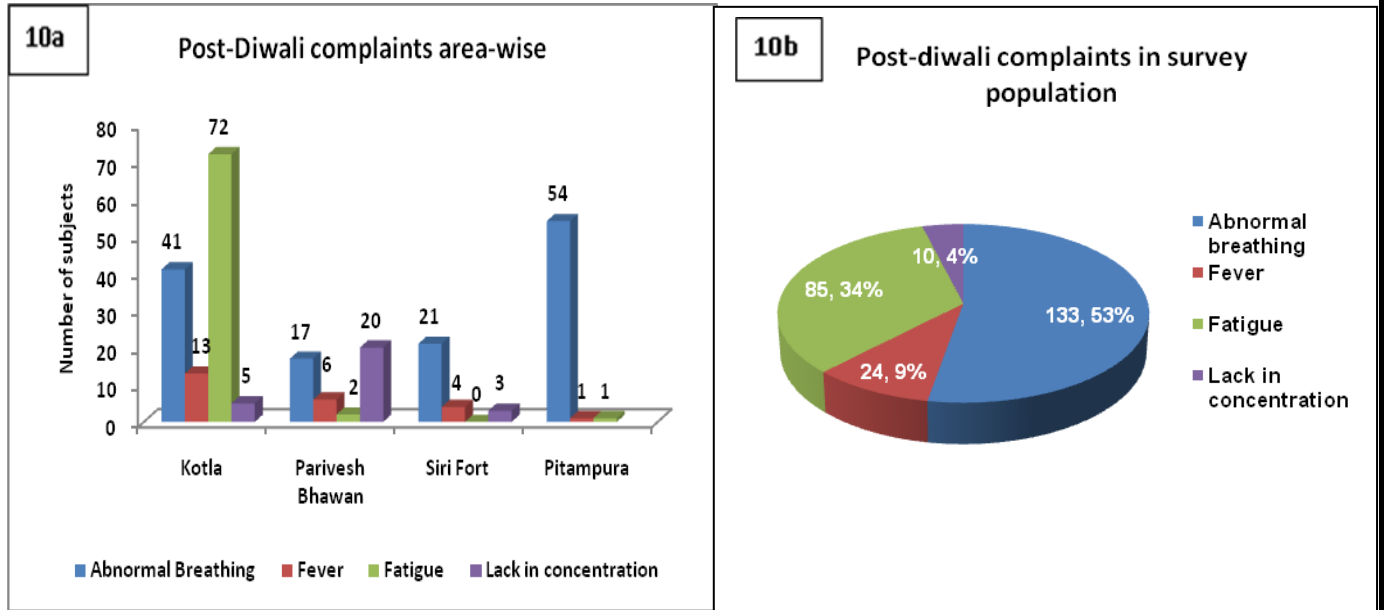


Figure 10: Post-diwali complaints area-wise and in survey population

ii. Health Problems

Headache, hair problem and itching was found to be 7.2%, 4.1% and 2.6% respectively in participants of Kotla and high blood pressure (6%) was reported in Parivesh Bhawan (Table 17), The distribution of health problems reported by survey population is shown in Figure 11.

Table 17: Post-Diwali health problems of 4 residential areas of Delhi

Health problems	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Headache	14 (7.2%)	5 (2.5%)	1 (0.5%)	1 (0.5%)
High Blood Pressure	5 (2.6%)	12 (6.0%)	2 (1.0%)	1 (0.5%)
Hair Problems	8 (4.1%)	0 (0%)	0 (0%)	0 (0%)
Itching	5 (2.6%)	0 (0%)	2 (1.0%)	0 (0%)

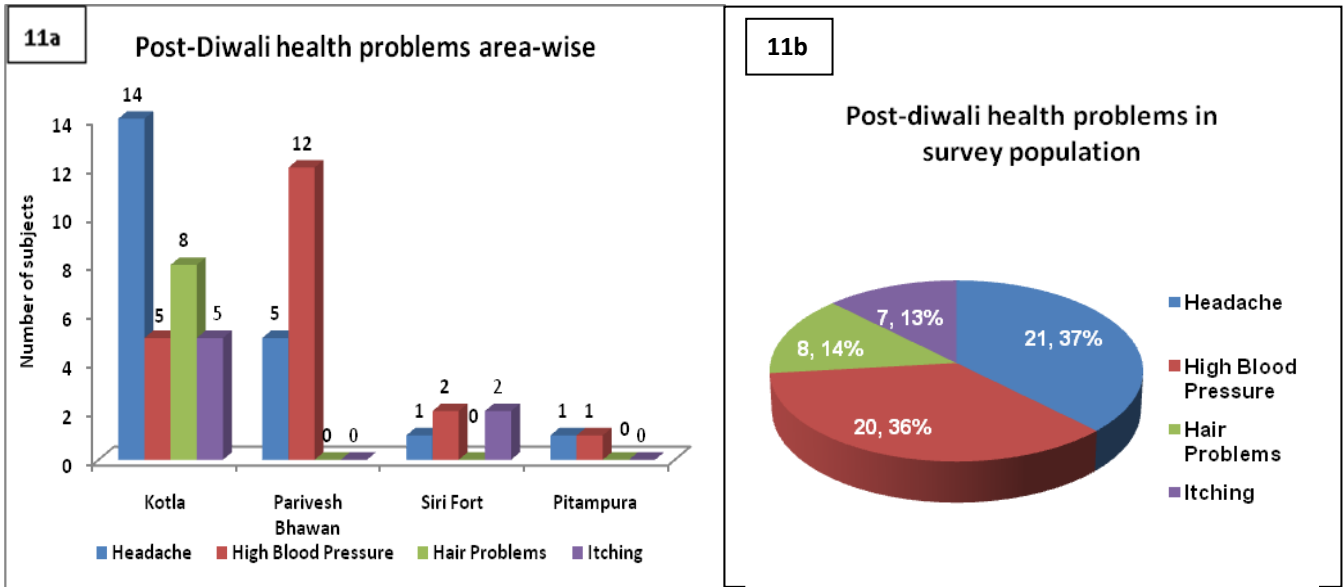


Figure 11: Post-Diwali health problems area-wise

iii. Comparison of respiratory disease between pre- and post-Diwali

The comparison of respiratory disease complaints was done between pre- and post-diwali. It was found that, there was a significant increase in the complaints of cough post-diwali among the participants of Kotla (6.7% vs 28.9%). However, there was significant decrease in cough and breathlessness post-diwali in Parivesh Bhawan, Moreover, there was significant decline in phlegm in Siri Fort and Pitampura (Table 18 & Figure 12).

Table 18: Comparison of respiratory disease pre- and post-Diwali

Symptoms	Pre-Diwali	Post-Diwali	p-value
Kotla	N=194	N=194	
Cough	13 (6.7%)	56 (28.9%)	0.0001*
Breathlessness	38 (19.6%)	36 (18.6%)	0.90
Cough with Phlegm	2/13	27/56	0.06
Parivesh Bhawan	N=201	N=201	
Cough	48 (23.9%)	17 (8.4%)	0.0001*
Breathlessness	56 (27.9%)	10 (5.0%)	0.0001*
Cough with Phlegm	7/48	1/17	0.67
Siri Fort	N=194	N=194	
Cough	29 (14.9%)	40 (20.6%)	0.18
Breathlessness	10 (5.2%)	3 (1.5%)	0.09
Cough with Phlegm	9/29	3/40	0.02*
Pitampura	N=199	N=198	
Cough	48 (24.1%)	58 (29.3%)	0.26
Breathlessness	36 (18.1%)	41 (20.7%)	0.45
Cough with Phlegm	44/48	33/58	0.0001*

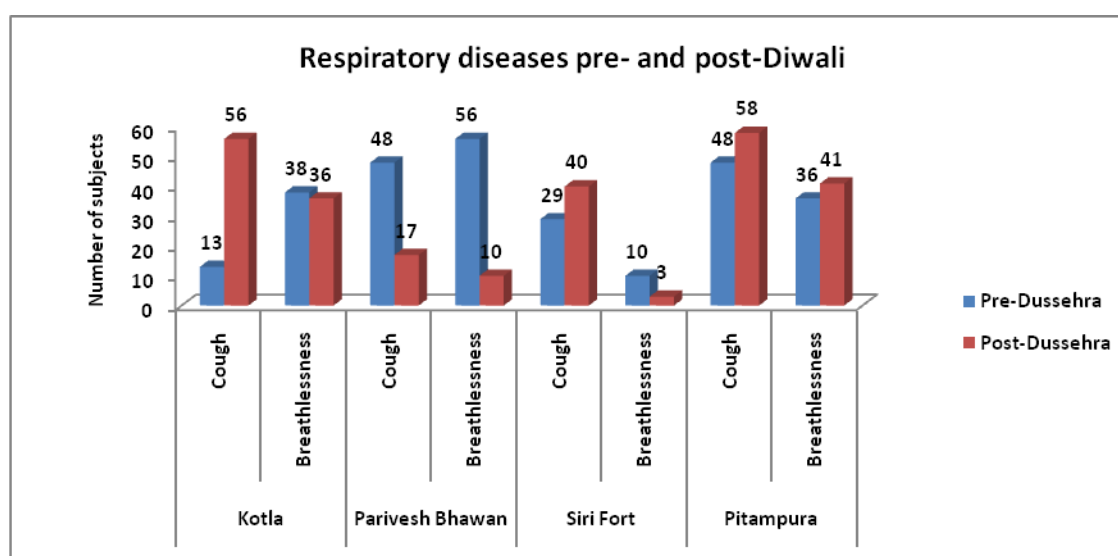


Figure 12: Respiratory diseases pre- and post-Diwali

iv. Noisy environment

34% participants from Siri Fort complained about noisy environment and 69.6% participants from Kotla were uncomfortable towards noise (Table 19). The distribution of noise complaints reported by survey population is shown in Figure 13.

Table 19: Post-Diwali noise complaints

Noise complaints	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Noisy environment	6 (3.1%)	23 (11.4%)	66 (34.0%)	53 (26.8%)
Uncomfortable noise	135 (69.6%)	126 (62.7%)	131 (67.5%)	68 (34.3%)
Lack in Concentration	5 (2.6%)	2 (1.0%)	0 (0%)	3 (1.5%)

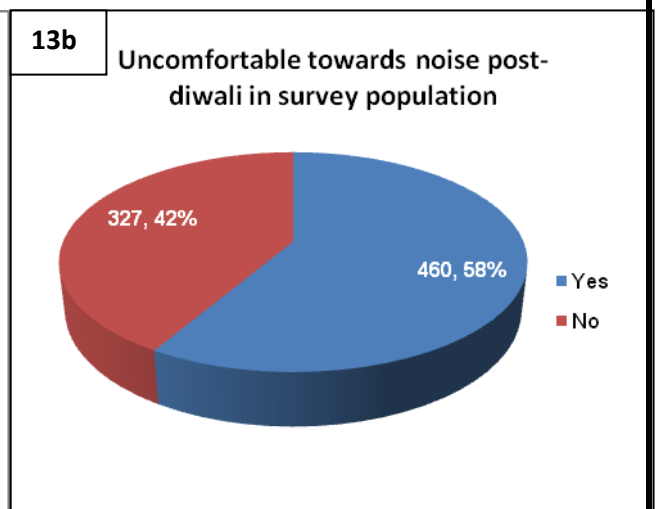
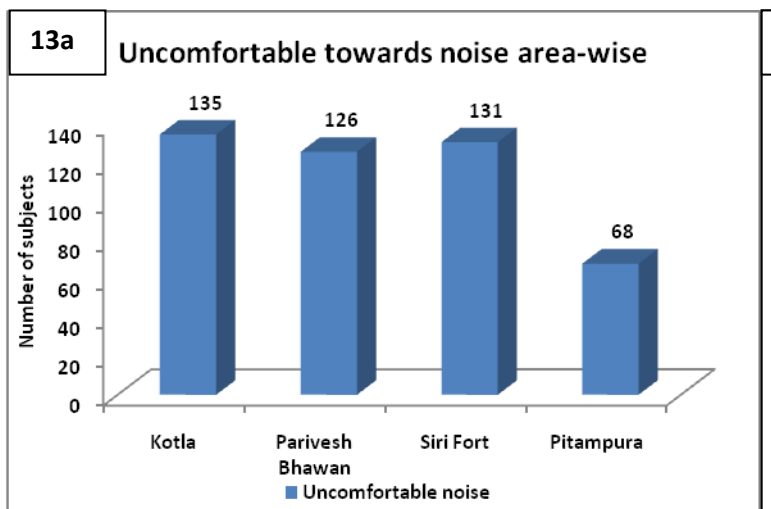


Figure 13: Uncomfortable towards noise Post-Diwali ar

v. Ear problems

The participants from Kotla reported maximum ear p participants had to increase the volume of TV to hear p ear problems reported by survey population is shown in

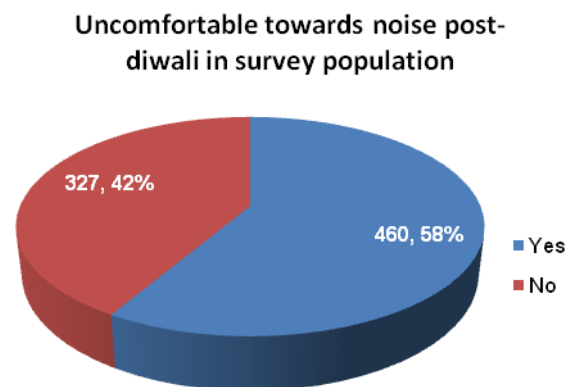


Table 20: Post-Diwali ear problems of 4 residential areas of Delhi

	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Ear Problems	33 (17.0%)	15 (7.5%)	10 (5.2)	7 (3.5%)
Complaint of ear	3/33	0/15	1/10	4/7
Ringing	5/33	0/15	4/10	0/7
Difficulty in hearing	1/33	0/15	0/10	0/7
Earlier hearing disease	7/33	2/15	1/10	3/7
Increased TV volume	8/33	6/15	3/10	0/7
Need to ask people to speak louder	4/33	4/15	1/10	0/7
Difficulty in understanding conversation	5/33	3/15	0/10	0/7

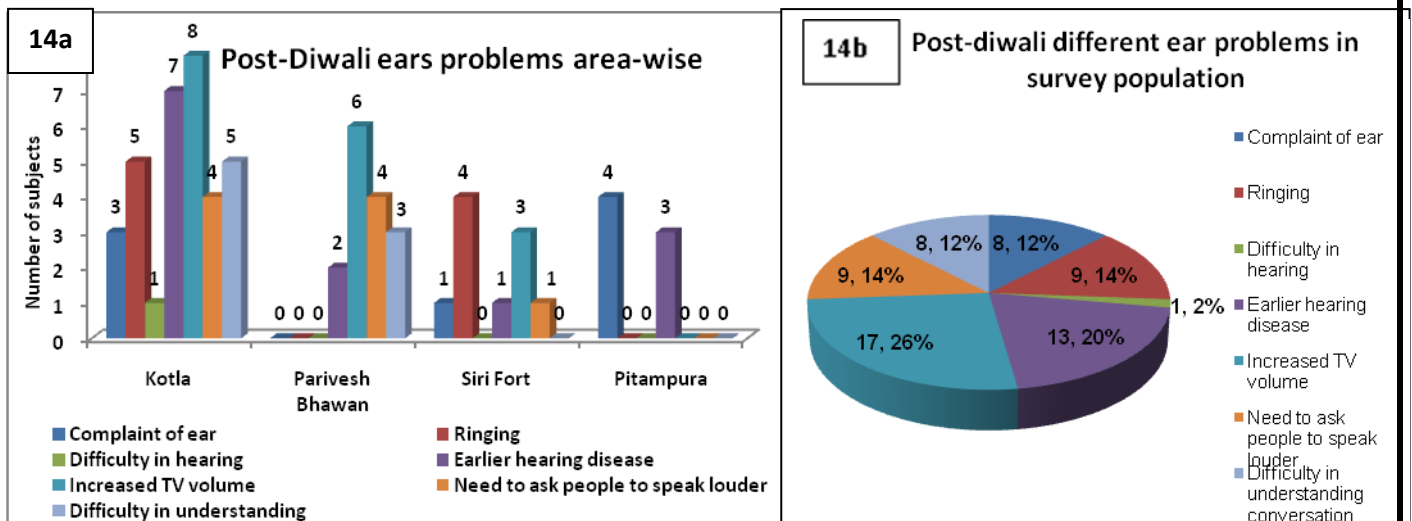


Figure 14: Post-diwali different ear problems in survey population

vi. Eye problems

The participants from Kotla and Pitampura reported maximum eye problems (48.5% & 43.4%), in which 19 (21.3%) participants had to watering of eyes (Table 21). The distribution of eye problems reported by survey population is shown in Figure 15.

Table 21: Post-Diwali eye problems of 4 residential areas of Delhi

	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Eye Problems	89 (48.5%)	18 (8.9%)	17 (9.8%)	86 (43.4%)
Black spot	4/94	0/18	1/19	2/86
Redness in eyes	17/94	7/18	16/19	29/86
Swelling in eyes	18/94	2/18	0/19	11/86
Burning in eyes	17/94	3/18	0/19	28/86
Watering from eyes	19/94	3/18	0/19	15/86
Blurring of eyes	6/94	1/18	0/19	1/86
Problem in watching television	8/94	2/18	0/19	0/86

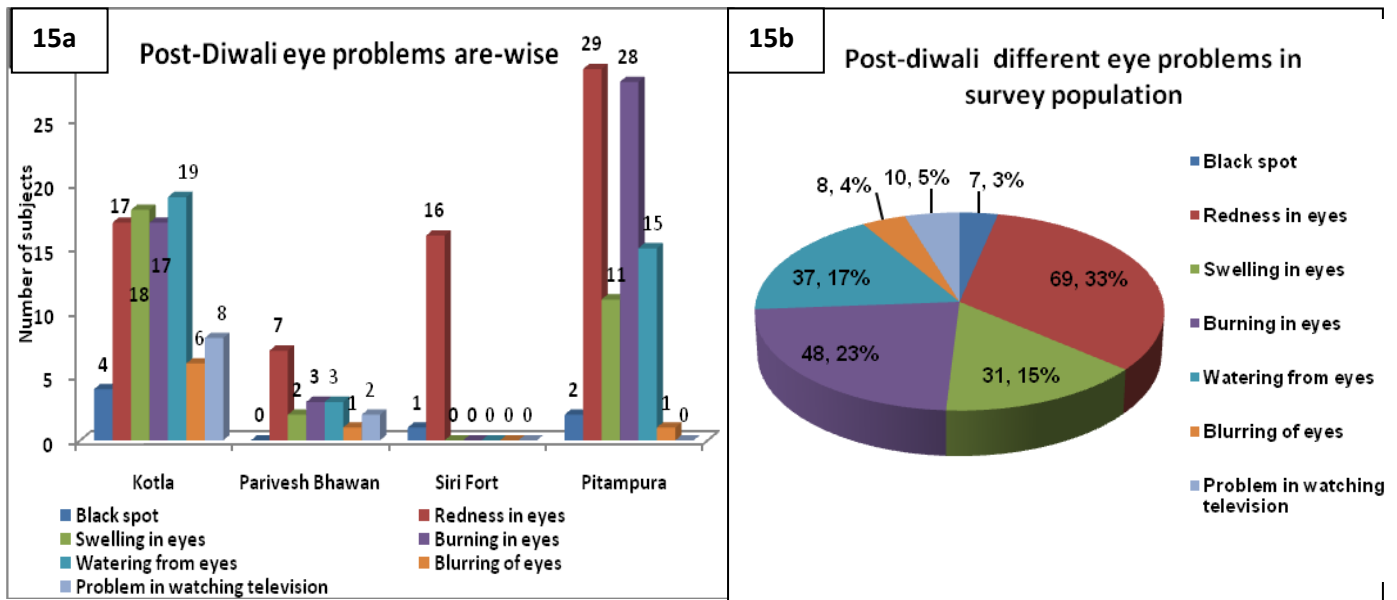


Figure 15: Post-diwali different eye problems in survey population

vii. Burns

Burn cases (3%) were reported from Parivesh Bhawan, Siri Fort and Pitampura (Table 22).

Table 22: Post-Diwali survey details of 4 residential areas of Delhi

	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Burns	2 (1.0%)	6 (3.0%)	6 (3.1%)	6 (3.0%)
Oil	0/2	0/2	1/6	0/6
Crackers	2/2	2/6	5/6	5/6
Electric	0/2	4/6	0/6	1/6

viii. Attitudinal issues towards bursting of crackers

Attitude of people towards the custom of using fire crackers is very important and was looked for in the survey population. The analysis revealed that about 13.5% interviewed felt that this custom should not be stopped, i.e. those who want to use and play with crackers should be allowed to do so. Another 70% were of the opinion that such bursting of fire crackers should be carried out in open spaces with community participation. 18% felt that only display of lights should be enough to celebrate the festival. The subjects who overwhelmingly felt that lights should only be used, belonged to Parivesh Bhawan. This is an area of Delhi which has relatively more educated population who also have a high socioeconomic status (Table 23 & Figure 16).

Table 23: Attitude towards bursting crackers of 4 residential areas of Delhi

Attitude towards crackers	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Idea of bursting crackers	188 (97.0%)	93 (46.3%)	174 (89.7%)	176 (88.9%)
Must not be stopped	22/188	2/93	52/174	9/176
Should be done in open spaces	144/188	24/93	104/174	168/176
Light should be used	22/188	67/93	18/174	9/176

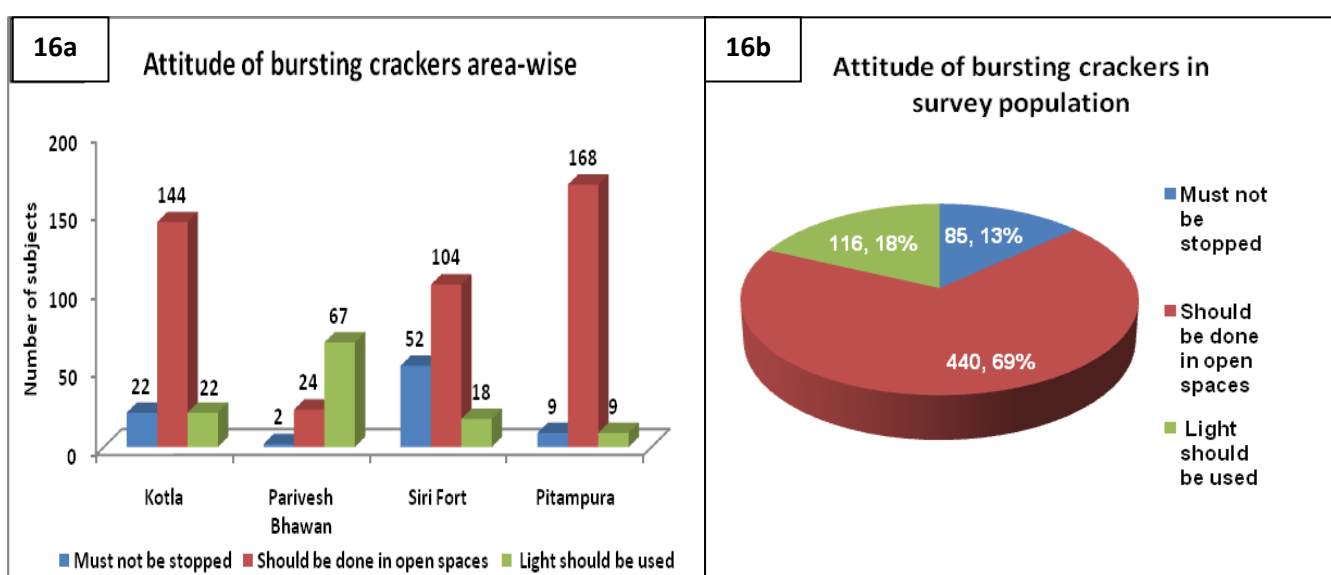


Figure 16: Attitude of bursting crackers in survey population

III. HOSPITAL ADMISSION PRE- AND POST-DIWALI:

The data of admission pre- and post-Diwali was collected from 20 hospitals of Delhi in a prescribed format. The details of hospital admission pre- and post-Diwali are shown in Table 24 and the details of hospital admission pre- and post-Diwali due to cardiac problems, stroke, respiratory problems and burns are shown in Table 25.

Table 24: Details of hospital showing pre- and post-Dussehra admissions

S.No.	Hospitals	Admission	
		Pre-Diwali	Post-Diwali
1.	All India Institute of Medical Sciences	3491	1442
2.	Dr. B.R Sur Homeopathic Medical College and Research Institute	17	12
3.	Deep Chand Bhandu Hospital	268	493
4.	Delhi Heart and Lung Institute	178	102
5.	ESI Hospital, Basaidharapur	761	205
6.	G.B. Pant Hospital	42	61
7.	Hindu Rao Hospital	283	282
8.	Jaipur Golden Hospital	16	14
9.	Lady Hardinge	5	7
10.	Lok Nayak Hospital	101	124
11.	Max Hospital, Patparganj	300	167
12.	Max Hospital, Saket	23	22
13.	MGS Hospital	3	5
14.	Primus Hospital	16	32
15.	Pushpawati Singhaniya	1	3
16.	Sardar Vallabh Bhai Patel Hospital	62	162
17.	Shanti Mukund Hospital	1	3
18.	Sri Balaji Action Medical Institute 1	331	178
19.	Sunder Lal Jain Hospital	6	9
20.	Tirath Ram Hospital	2	1
	Total	5907	3324

Table 25: Details of hospital showing pre- and post-Dussehra admissions

S.No.	Hospitals	Admission			
		Cardiac Problems	Stroke	Respiratory Problems	Burns
		Pre-/Post-Diwali	Pre-/Post-Diwali	Pre-/Post-Diwali	Pre-/Post-Diwali
1.	All India Institute of Medical Sciences	2262/1141	840/287	389/14	0/0
2.	Dr. B.R Sur Homeopathic Medical College and Research Institute	0/0	0/0	17/12	0/0
3.	Deep Chand Bhandu Hospital	80/115	6/3	182/375	0/0
4.	Delhi Heart and Lung Institute	106/70	0/0	75/32	0/0
5.	ESI Hospital, Basaidharapur	382/91	0/0	379/114	0/0
6.	G.B. Pant Hospital	40/59	2/2	0/0	0/0
7.	Hindu Rao Hospital	118/120	73/76	92/86	0/0
8.	Jaipur Golden Hospital	5/3	2/2	9/9	0/0
9.	Lady Hardinge	1/0	3/1	1/6	0/0
10.	Lok Nayak Hospital	50/67	10/6	34/43	7/8
11.	Max Hospital, Patparganj	92/31	122/68	86/68	0/0
12.	Max Hospital, Saket	6/12	3/0	14/10	0/0
13.	MGS Hospital	0/0	0/0	3/5	0/0
14.	Primus Hospital	4/8	0/2	12/22	0/0
15.	Pushpawati Singhaniya	0/0	1/0	0/3	0/0
16.	Sardar Vallabh Bhai Patel Hospital	23/68	0/1	39/93	0/0
17.	Shanti Mukund Hospital	0/0	0/0	1/3	0/0
18.	Sri Balaji Action Medical Institute 1	111/67	127/79	92/29	1/3
19.	Sunder Lal Jain Hospital	3/4	0/1	3/4	0/0
20.	Tirath Ram Hospital	0/0	0/0	2/1	0/0
	Total				

There was increase in hospital admission post-diwali in 10 (50%) hospitals (Table 26 & Figure 17). The highest and lowest number of hospital admission was seen in Deep Chand Bhandu Hospital (493) and Shanti Mukund Hospital and Puspawati Singhaniya Hospital (3 each). However, around 11 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke. The Deep Chand Bhandu Hospital showed significant increase in hospital admission post-Diwali as compared to other hospitals.

Table 26: Details of hospital showing increased admission post-Diwali

Hospitals	Admission	
	Pre-Diwali	Post-Diwali
GB Pant Hospital	42	61
LNJP Hospital	101	124
Sardar VB Patel Hospital	62	162
Sunder Lal Jain Hospital	6	9
Shanti Mukund Hospital	1	3
Deep Chand Bhandu Hospital	268	493
Puspawati Singhaniya Hospital	1	3
MGS Hospital	3	5
Lady Hardinge Hospital	5	7
Primus Hospital	16	32

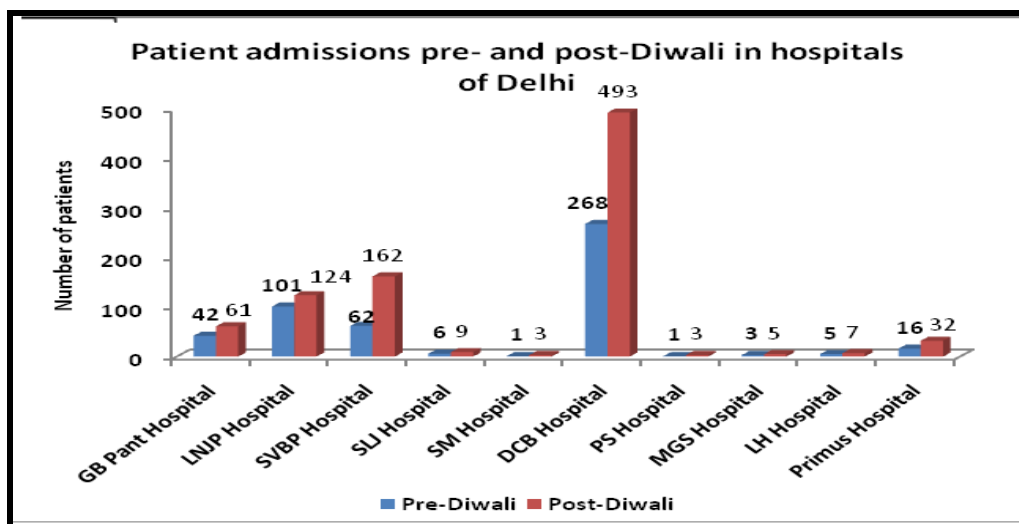


Figure 17: Distribution of admission to hospitals pre- and post-Diwali

a) Cardiac problems

There was increase in hospital admission due to cardiac problem post-diwali in 8 (40%) hospitals (Table 27 & Figure 18). The highest and lowest percentage increase of hospital

admission due to cardiac problems was seen in Sardar VB Patel Hospital 196.5% and Hindu Rao Hospital 1.7%, respectively. However, around 13 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke. The Deep Chand Bhandu Hospital and Sardar Vallabh Bhai Patel Hospital showed significant increase in cardiac problems post-Diwali as compared to other hospitals.

Table 27: Hospital showing increased admission due to cardiac problems

Hospitals	Cardiac Problems	
	Pre-Diwali	Post-Diwali
GB Pant Hospital	40	59
LNJP Hospital	50	67
Sardar VB Patel Hospital	23	68
Hindu Rao Hospital	118	120
Sunder Lal Jain Hospital	3	4
Deep Chand Bhandu Hospital	80	115
Max Hospital Saket	6	12
Primus Hospital	4	8

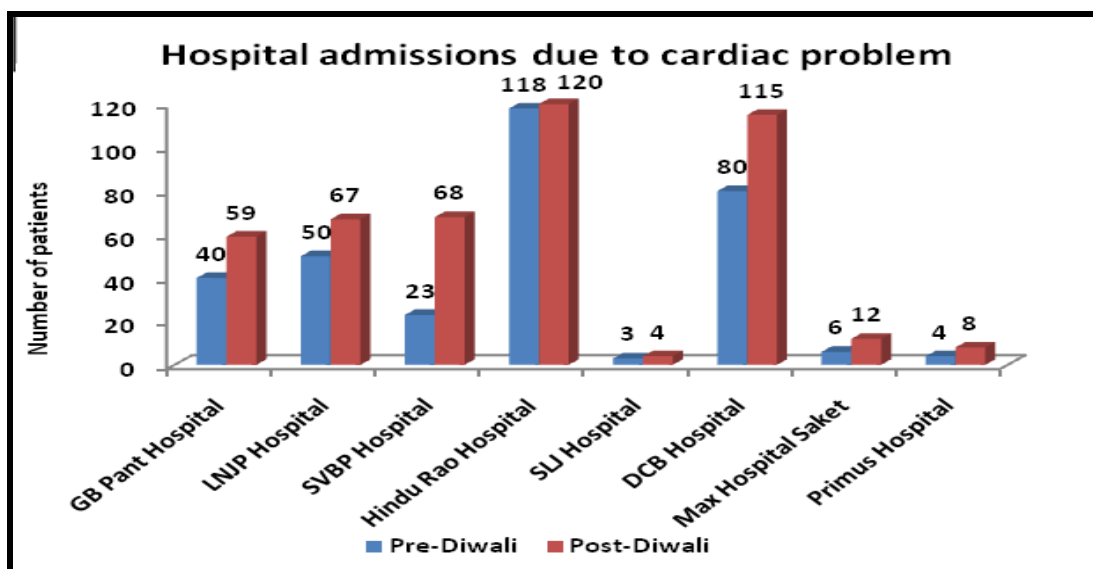


Figure 18: Hospital admission due to cardiac problems pre- and post-Diwali

b) Stroke

There was increase in hospital admission due to stroke post-diwali in 4 (20%) hospitals (Table 28 & Figure 19). The highest number of hospital admission due to stroke was seen in Hindu Rao Hospital (73 vs 76) and lowest number of hospital admission due to stroke was

seen in Sunder Lal Jain Hospital & Sardar VB Patel Hospital (1 each). However, around 17 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke.

Table 28: Hospital showing increased admission due to stroke

Hospitals	Stroke	
	Pre-Diwali	Post-Diwali
Sardar Vallabh Bhai Patel Hospital	0	1
Hindu Rao Hospital	73	76
Sunder Lal Jain Hospital	0	1
Primus Hospital	0	2

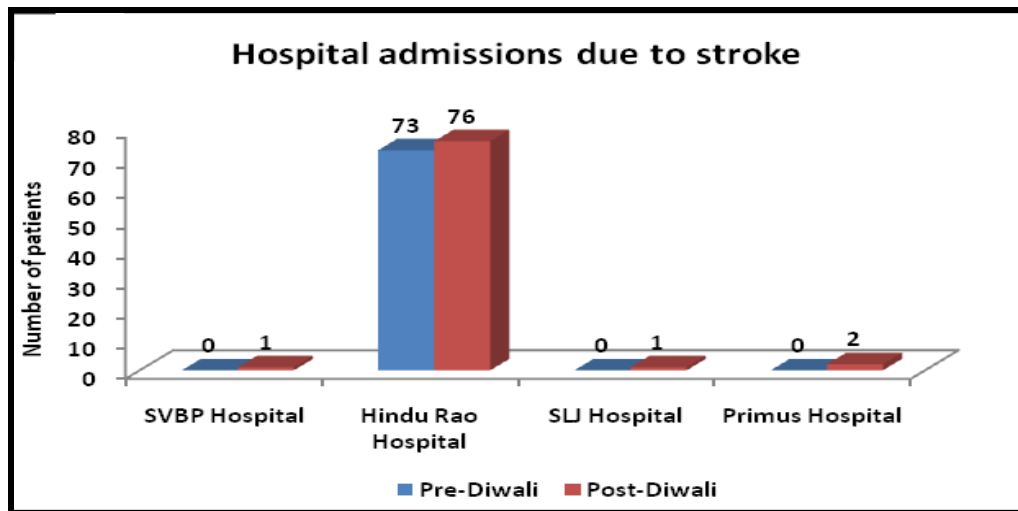


Figure 19: Hospital admissions due to stroke pre- and post-Diwali

c) Respiratory problems

There was increase in hospital admission due to respiratory problems post-diwali in 9 (45%) hospitals (Table 29 & Figure 20). The highest number of hospital admission due to respiratory problems was seen in Deep Chand Bhandu Hospital (375) and lowest number of hospital admission due to respiratory problems was seen in Shanti Mukund Hospital & Puspawati Singhaniya Hospital (3 each). However, around 12 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke. The Deep Chand Bhandu Hospital and Sardar Vallabh Bhai Patel Hospital showed significant increase in respiratory problems post-Diwali as compared to other hospitals.

Table 29: Hospital showing increased admission due to respiratory problems

Hospitals	Respiratory problems	
	Pre-Diwali	Post-Diwali
LNJP Hospital	34	63
Sardar VB Patel Hospital	39	93
Sunder Lal Jain Hospital	3	4
Shanti Mukund Hospital	1	3
Deep Chand Bhandu Hospital	182	375
Puspawati Singhaniya Hospital	0	3
MGS Hospital	3	5
Lady Hardinge	1	6
Primus Hospital	12	22

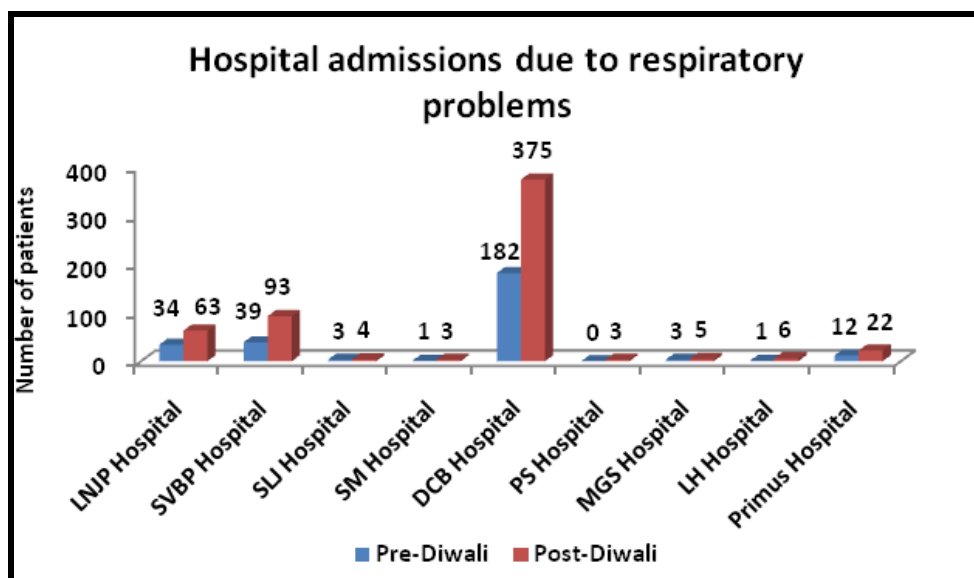


Figure 20: Hospital admission due to respiratory problems pre- and post-Diwali

d) Burns

There was increase in hospital admission due to burns post-dussehra in 2 (10%) hospitals (Table 30 & Figure 21). However, around 19 hospitals did not show any increase in hospital admissions/visits for respiratory, cardiac and stroke.

Table 30: Hospital showing increased admission due to burns

Hospitals	Burns	
	Pre-Diwali	Post-Diwali
Shri Balaji Hospital	1	3
LNJP Hospital	7	8

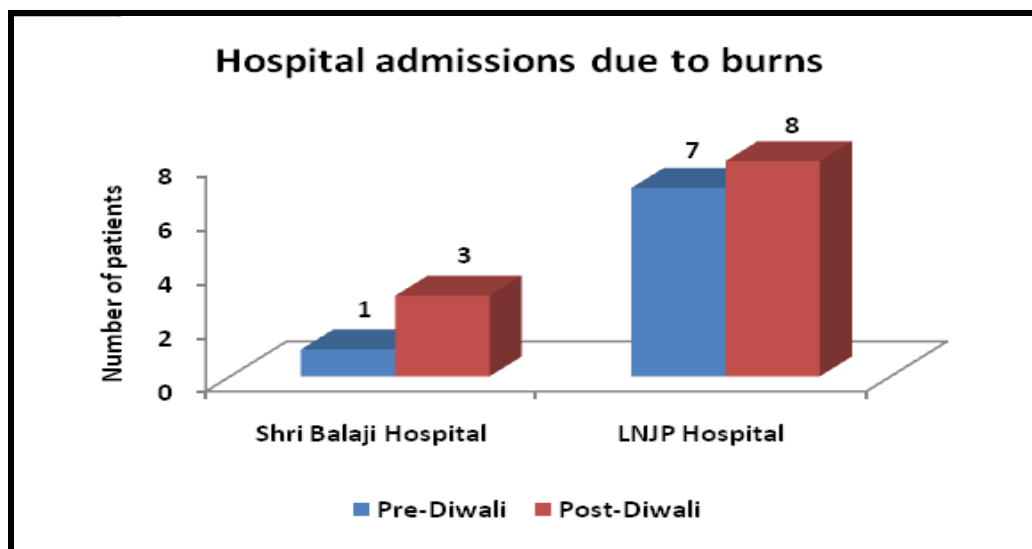


Figure 21: Hospital admission due to burns pre- and post-Diwali

IV. PULMONARY FUNCTION TESTING (PFT) - SPIROMETRY

The Pulmonary Function test was performed in certain percentage of survey population pre- and post-Diwali to assess the effect of bursting crackers on respiratory functions. Except Kotla all other places did not show any change in FEV1/FVC ratio and it was within normal range. FEV1/FVC ratio signifies airway obstructive disease. However, the change was statistically insignificant (Table 31 & Figure 22).

Table 31: Distribution of FEV1/FVC pre- and post-Diwali in patients from different places in Delhi

FEV1/FVC	Pre-Diwali	Post-Diwali	p-value
Kotla	N=60	N=47	
<70%	2 (3.3%)	2 (4.3%)	0.98
≥70%	58 (96.7)	45 (95.7%)	
Parivesh Bhawan	N=57	N=47	
<70%	2 (3.5)	0 (0%)	0.74
≥70%	55 (96.5)	47 (100%)	
Siri Fort	N=41	N=38	
<70%	1 (2.4)	0 (0%)	1.00
≥70%	40 (97.6)	38 (100%)	
Pitampura	N=52	N=32	
<70%	1 (1.9)	0 (0%)	1.00

≥70%	51 (98.1)	32 (100%)	
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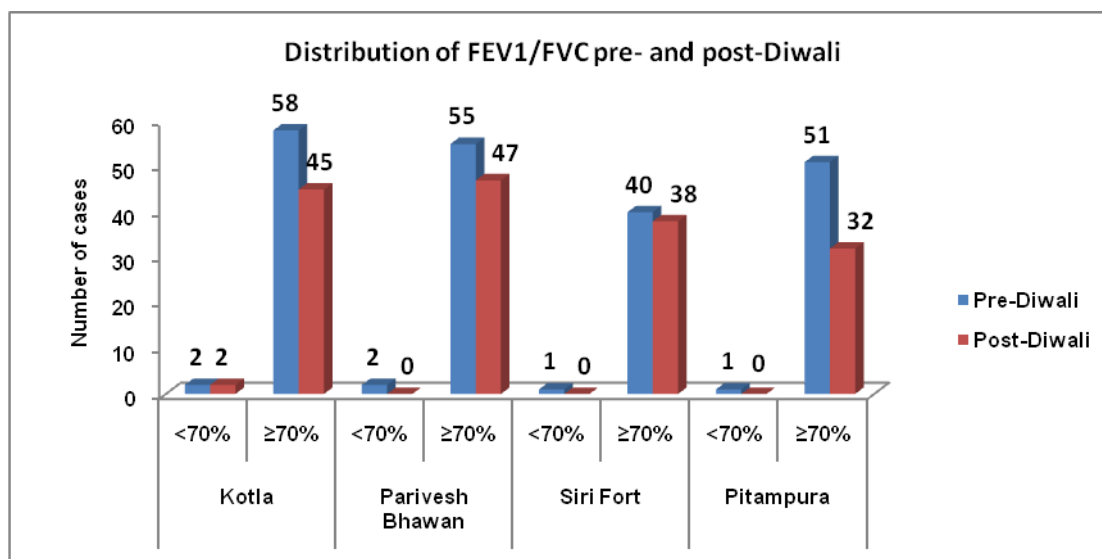


Figure 22: Distribution of FEV1/FVC pre- and post-Diwali

V. AMBIENT NOISE LEVEL

Both pre- and post-Diwali ambient noise level showed significantly higher levels at night as compared to the day in all the areas. However, ambient noise level of Siri Fort showed significant increase post-Diwali during day (4 dB vs 18 dB). Further, ambient noise level of Parivesh Bhawan showed significant increase post-Diwali during night (1.8 dB vs 7.3 dB) (Table 32 & Figure 23).

Table 32: Percentage change in ambient noise level pre- and post-Diwali

Place	Percentage change in noise level (dB)			
	Pre-Diwali		Post-Diwali	
	Day	Night	Day	Night
Kotla	12.3	23.6	9.2	23.6
Parivesh Bhawan	1.5	1.8	-1.5	7.3
Siri Fort	4	30	18	32.5
Pitampura	9.1	31.1	3.6	20

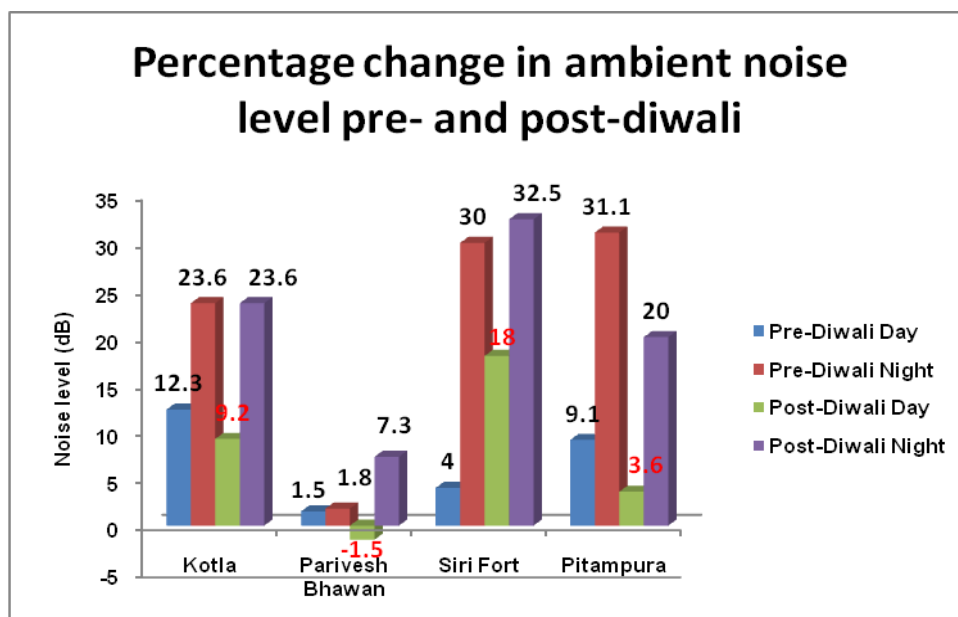


Figure 23: Percentage change in ambient noise level pre- and post-diwali area-wise

a) Ambient noise level and ear problems

There was no association between percentage change in ambient noise level and ear problems. Kotla participants complained 17% ear problem at an increase in ambient noise level by 9.2 / 23.6 dB (D/N) while Siri Fort participants complained 5.2% ear problem at an higher ambient noise level 18 / 32.5 dB (D/N) (Table 33).

Table 33: Comparison of Ambient noise level post-Diwali with ear problems

	Kotla (N=194)	Parivesh Bhawan (N=201)	Siri Fort (N=194)	Pitampura (N=198)
Ambient noise level (dB) (D/N)	9.2 / 23.6	-1.5 / 7.3	18 / 32.5	3.6 / 20
Ear Problems	33 (17.0%)	15 (7.5%)	10 (5.2%)	7 (3.5%)
Complaint of ear	3/33	0/15	1/10	4/7
ringing	5/33	0/15	4/10	0/7
Difficulty in hearing	1/33	0/15	0/10	0/7
Earlier hearing disease	7/33	2/15	1/10	3/7
Increased TV volume	8/33	6/15	3/10	0/7
Need to ask people to speak louder	4/33	4/15	1/10	0/7
Difficulty in understanding conversation	5/33	3/15	0/10	0/7
Uncomfortable noise	135 (69.6%)	126 (62.7%)	131 (67.5%)	68 (34.3%)
Lack in Concentration	5 (2.6%)	2 (1.0%)	0 (0%)	3 (1.5%)

Ambient air quality

The ambient air quality of 3 residential areas were within normal limits both pre- and post-Diwali with respect to SO₂ and NO₂ but there was increase in levels of PM₁₀ and PM_{2.5} post-Diwali (Table 34 & Figure 24).

Table 34: Ambient air quality pre- and post-Diwali

	24 - hourly Standards in µg/m ³	Pre-Diwali (in µg/m ³)	Post-Diwali (in µg/m ³)
Kotla			
SO ₂	80	7	15
NO ₂	80	87	80
PM ₁₀	100	208	245
PM _{2.5}	60	132	192
Parivesh Bhawan			
SO ₂	80	13	38
NO ₂	80	66	61
PM ₁₀	100	272	296
PM _{2.5}	60	158	167
Pitampura			
SO ₂	80	13	11
NO ₂	80	73	66
PM ₁₀	100	226	324
PM _{2.5}	60	147	134

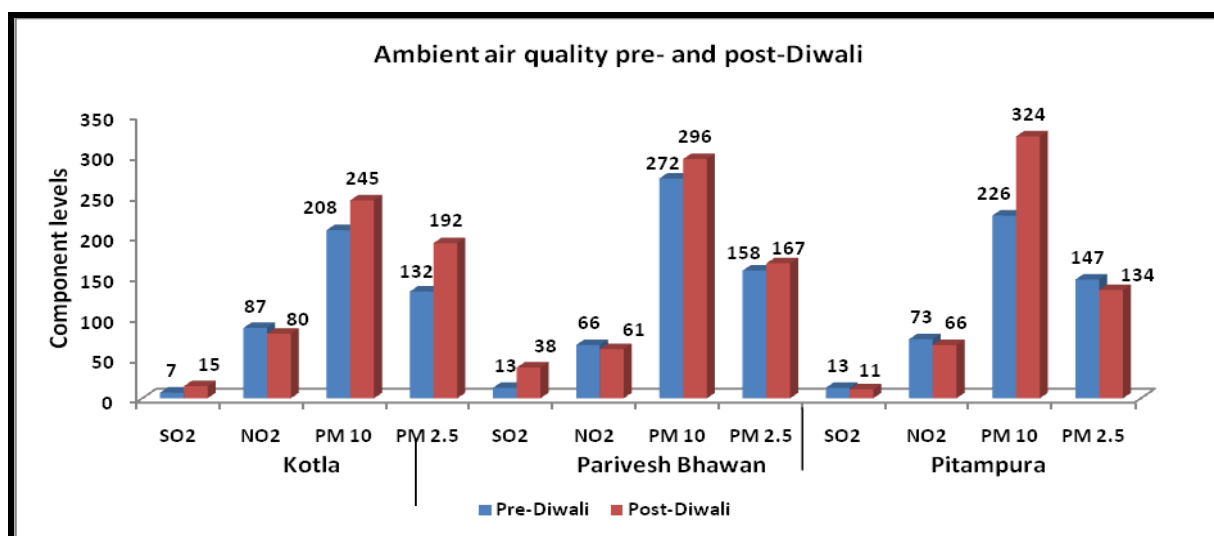


Figure 24: Ambient air quality pre- and post-Diwali

b) Ambient air quality and respiratory problems

There was increased complaints of respiratory problems due to increased PM₁₀ and PM_{2.5} concentration in air (Table 35).

Table 35: Ambient air quality and respiratory disease pre- and post-Diwali

Symptoms	Ambient air quality		p-value
	Pre-Diwali	Post-Diwali	
Kotla	N=194	N=194	
Cough	13 (6.7%)	56 (28.9%)	0.0001*
Breathlessness	38 (19.6%)	36 (18.6%)	0.90
Cough with Phlegm	2/13	27/56	0.06
Parivesh Bhawan	N=201	N=201	
Cough	48 (23.9%)	17 (8.4%)	0.0001*
Breathlessness	56 (27.9%)	10 (5.0%)	0.0001*
Cough with Phlegm	7/48	1/17	0.67
Pitampura	N=199	N=198	
Cough	48 (24.1%)	58 (29.3%)	0.26
Breathlessness	36 (18.1%)	41 (20.7%)	0.45
Cough with Phlegm	44/48	33/58	0.0001*

c) Ambient air quality and eye problems

There was increased complaints of eye problems due to increased PM₁₀ and PM_{2.5} concentration in air (Table 36).

Table 36: Ambient air quality and eyes problems

Ambient air quality	Kotla (N=194)	Parivesh Bhawan (N=201)	Pitampura (N=198)
Eye Problems	89 (48.5%)	18 (8.9%)	86 (43.4%)
Black spot	4/94	0/18	2/86
Redness in eyes	17/94	7/18	29/86
Swelling in eyes	18/94	2/18	11/86
Burning in eyes	17/94	3/18	28/86
Watering from eyes	19/94	3/18	15/86
Blurring of eyes	6/94	1/18	1/86
Problem in watching television	8/94	2/18	0/86

VI. Element levels in urine samples of 4 residential areas post-Diwali

The levels of Mercury and Antimony were not detectable in urine samples of all the 4 areas. The level of Arsenic in urine was found to be within the permissible limits, while the level of Barium in urine was above the permissible limits in all the 4 areas. The urine level of lead was above permissible limit in (9/10) sample in Siri Fort area. The urine level of strontium was above permissible limit in (4/10) sample in Siri Fort and Parivesh Bhawan areas. Other areas also showed high lead and strontium levels (Table 37, 38 and Figure 25).

It is pertinent to note that the permitted metals as per Controller of Explosives and Fireworks the allowed components of fire crackers are mainly Barium Nitrate, Potassium Nitrate, Sulphur, Charcoal and Strontium.

Table 37: Elements urine level with respect to normal limits

	Urine levels			
	Lead		Strontium	
	$\leq 0.667 \mu\text{g/L}$	$> 0.667 \mu\text{g/L}$	$< 0.03 \mu\text{g/L}$	$\geq 0.03 \mu\text{g/L}$
Kotla	4 (40%)	6 (60%)	8 (80%)	2 (20%)
Parivesh Bhawan	8 (80%)	2 (20%)	6 (60%)	4 (40%)
Siri Fort	1 (10%)	9 (90%)	6 (60%)	4 (40%)
Pitampura	8 (80%)	2 (20%)	7 (70%)	3 (30%)

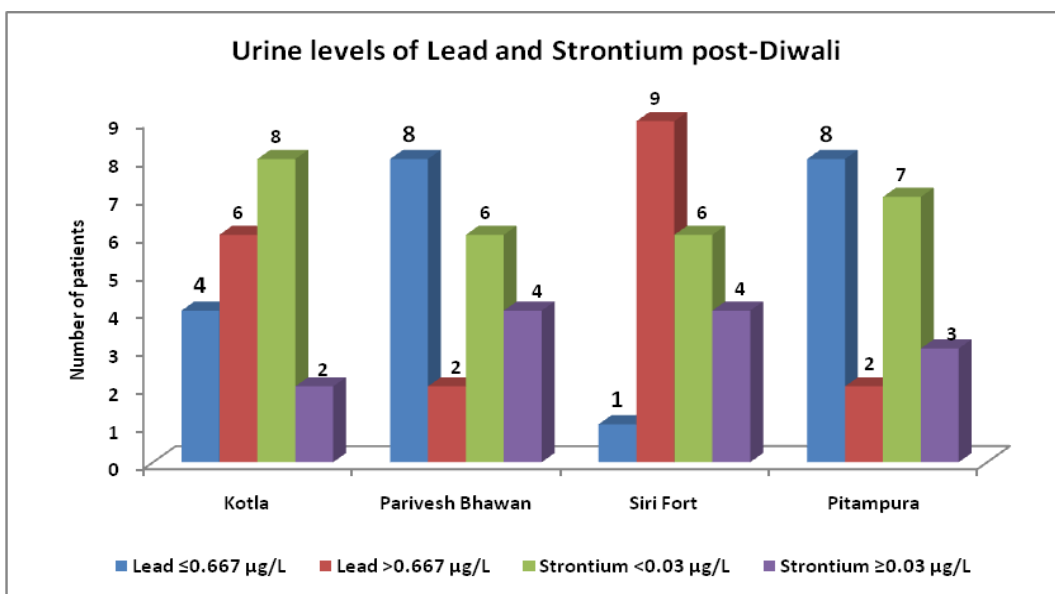


Figure 25: Urine levels of Lead and Strontium post-Diwali

Table 38: Element levels in urine post-Diwali

Elements mean±SD (Range) [Median]	Kotla	Parivesh Bhawan	Siri Fort	Pitampura
	N=10	N=10	N=10	N=10
Arsenic (µg/L)	16.18±9.77 (10-40) [10.11]	28.3±17.71 (10-61) [20.22]	13.15±12.66 (0-40) [10.11]	17.19±20.81 (0-61) [10.11]
Lead (µg/L)	16.18±21.95 (0-71) [10.11]	8.09±22.26 (0-71) [0.00]	220.44±505.64 (0-1648) [50.56]	4.04±8.53 (0-20) [0.00]
Mercury (µg/L)	Not Detected	Not Detected	Not Detected	Not Detected
Strontium (µg/L)	2.81±4.5 (0.01-12.0) [0.01]	2224.64±3081.90 (0-8090) [0.00]	1820.16±4517.20 (0-14157) [0.00]	1921.28±3675.42 (0-11123) [0.00]
Barium (µg/L)	0.06±0.03 (0.03-0.10) [0.06]	76.85±42.69 (40-111) [65.73]	114.27±50.23 (51-192) [96.06]	84.94±65.74 (40-263) [60.67]
Antimony (µg/L)	Not Detected	Not Detected	Not Detected	Not Detected
Potassium (mEq/L)	1671±1450.22 (328-4793) [1212]	48.50±29.04 (15-118) [43.59]	35.0±30.79 (11-108) [22.80]	54.38±47.09 (7-170) [44.64]
Sulphur (µg/L)	739.4±487.84 (235-1915) [695.5]	27.36±22.05 (9-85) [23.08]	14.65±15.94 (3-55) [9.69]	19.53±19.66 (3-68) [13.57]

The elements of PM_{2.5} and urine level of the metals in subjects of Parivesh Bhawan and Pitampura are shown in Table 39.

Table 39: Element levels in air and urine

mean±SD (Range) [Median]	Elements in PM _{2.5} Post-Diwali							
	Arsenic (µg/m ³)	Lead (µg/m ³)	Mercury (µg/m ³)	Strontium (µg/m ³)	Barium (µg/m ³)	Antimony (µg/m ³)	Potassium (µg/m ³)	Sulfur (µg/m ³)
Parivesh Bhawan (Air levels)				0.01	0.40	0.07	6.78	8.13
Urine levels (µg/L)	28.3±17.71 (10-61) [20.22]	8.09±22.26 (0-71) [0.00]	Not Detected	2224.64±3081.90 (0-8090) [0.00]	76.85±42.69 (40-111) [65.73]	Not Detected	48.50±29.04 (15-118) [43.59]	27.36±22.05 (9-85) [23.08]
	Arsenic (µg/m ³)	Lead (µg/m ³)	Mercury (µg/m ³)	Strontium (µg/m ³)	Barium (µg/m ³)	Antimony (µg/m ³)	Potassium (µg/m ³)	Sulfur (µg/m ³)
Pitampura (Air levels)				0.01	0.54	0.02	6.30	8.60
Urine levels (µg/L)	17.19±20.81 (0-61) [10.11]	4.04±8.53 (0-20) [0.00]	Not Detected	1921.28±3675.42 (0-11123) [0.00]	84.94±65.74 (40-263) [60.67]	Not Detected	54.38±47.09 (7-170) [44.64]	19.53±19.66 (3-68) [13.57]

VII. TRENDS OF VARIOUS ELEMENTS IN PM_{2.5} DURING DIWALI

a) Sulfur

Short-term exposures to sulfur can harm the human respiratory system and make breathing difficult. Children, the elderly, and those who suffer from asthma are particularly sensitive to effects (USEPA).

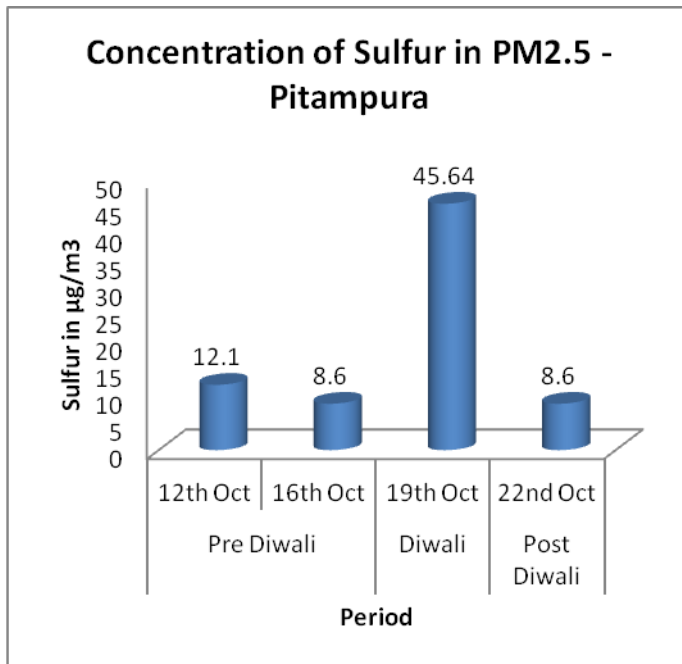


Figure 26a

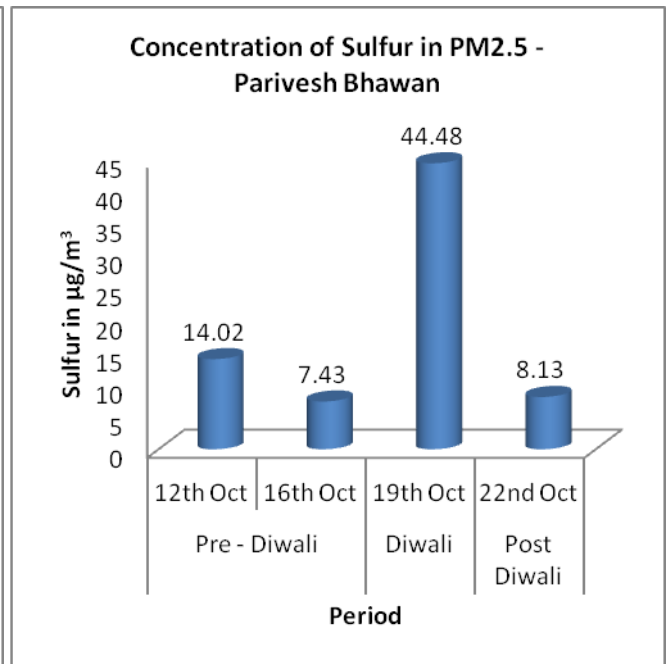


Figure 26b

It can be seen from above figures that the concentration of Sulfur was as high as 45.64 µg/m³ on the day of Diwali as compared to pre and post festival days in Pitampura. Same scenario can be seen for Parivesh Bhawan during Diwali day, when value of sulfur is monitored at 44.8 µg/m³ as compared to before and after Diwali period.

b) Chlorine

Chlorine is a potent irritant to the eyes, the upper respiratory tract, and lungs.

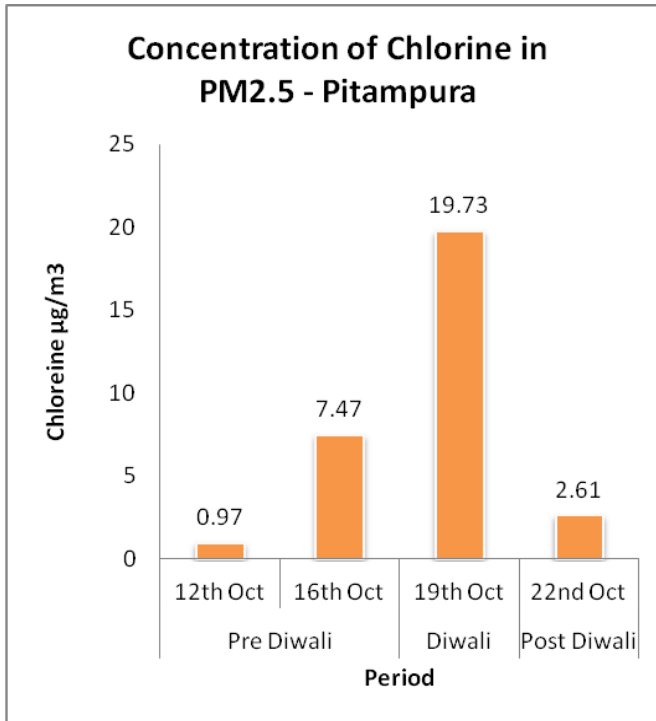


Figure 27a

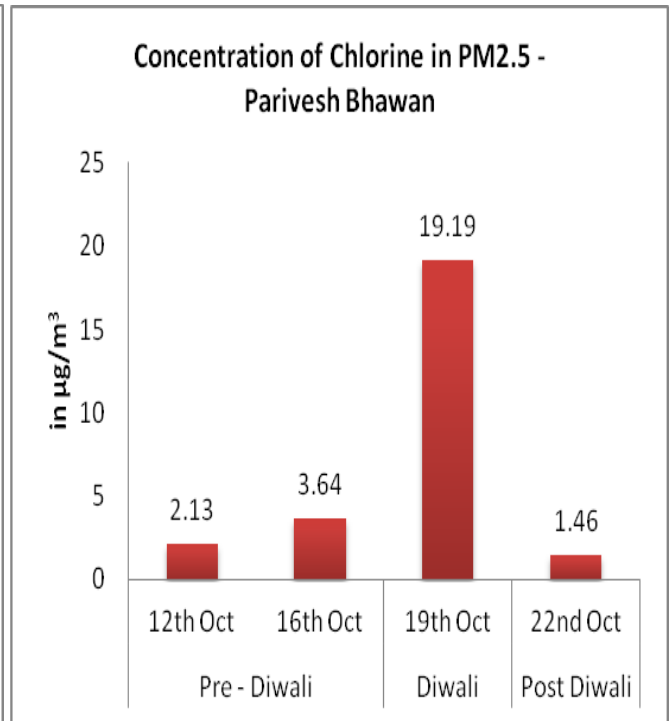


Figure 27b

On Diwali day value of Chlorine in $\text{PM}_{2.5}$ was $19.73 \mu\text{g}/\text{m}^3$ as compared to days before and after festival in Pitampura area. In Parivesh Bhawan area too, Chlorine has reached the point of $19.19 \mu\text{g}/\text{m}^3$, which is as high in contrast to the period of pre and post Diwali.

c) Potassium

Excessive potassium can lead to hyperkalemia.

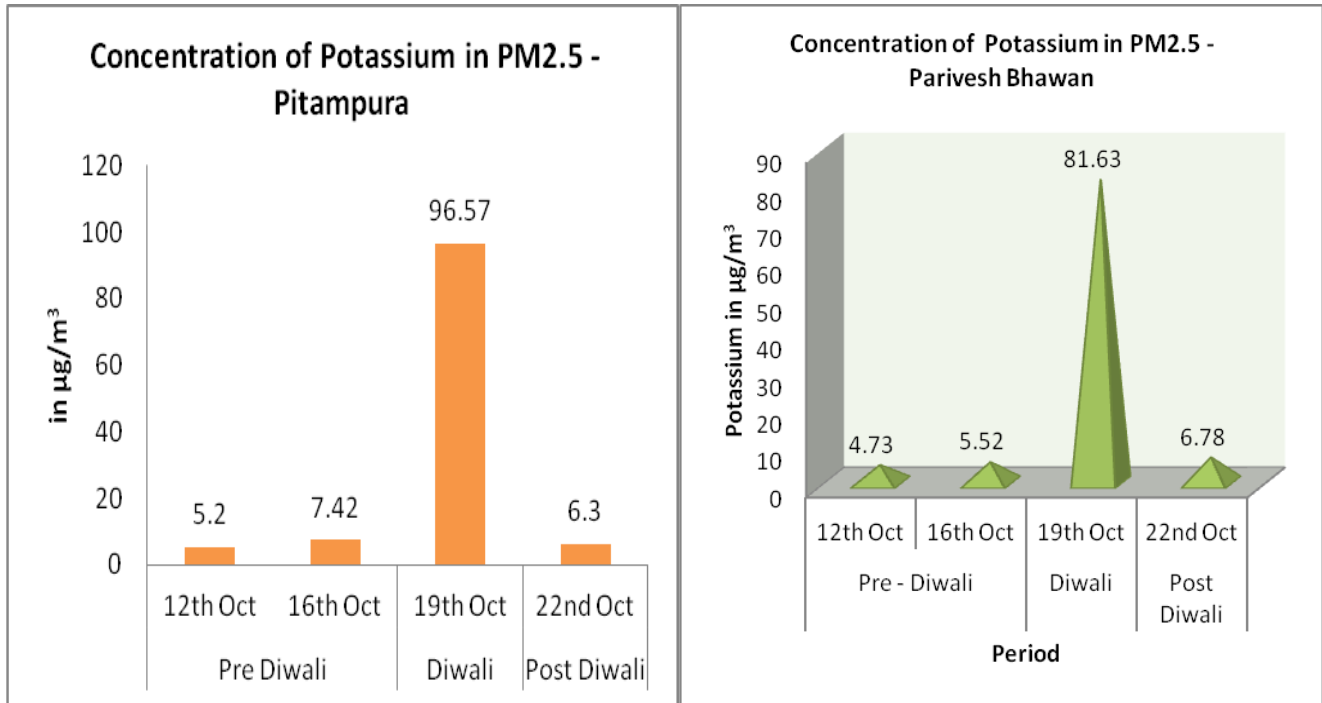


Figure 28a

Figure 28b

Concentration of Potassium in PM_{2.5} has risen from 7.42 µg/m³ on 16 October, 2017 (pre – diwali) to 96.57 µg/m³ on the day of Diwali and fallen down to 6.3 µg/m³ on 22 October, 2017 (after Diwali) in Pitampura. Same situation can be observed in the area of Parivesh Bhawan i.e. Potassium is high on the day of Diwali as compared to before and after festival days.

d) Calcium:

Abnormally high calcium concentrations activates a series of inflammatory reactions, leading to inflammation and cell damage.

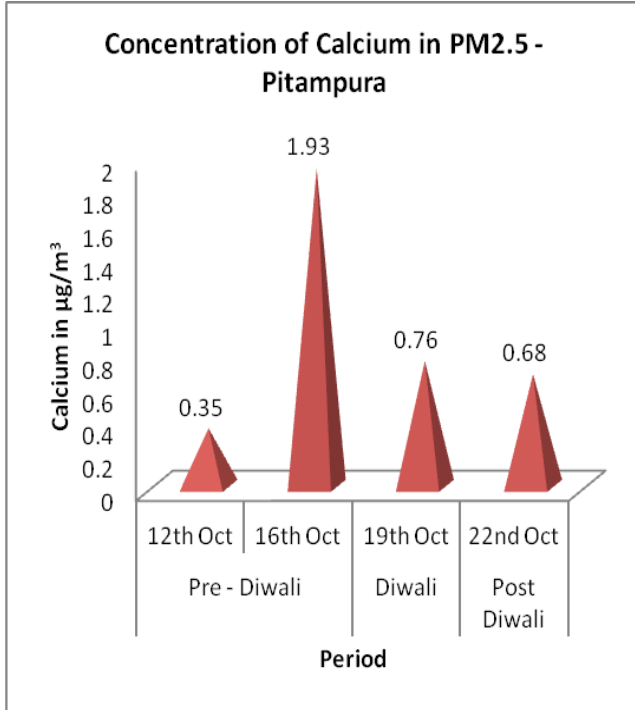


Figure 29a

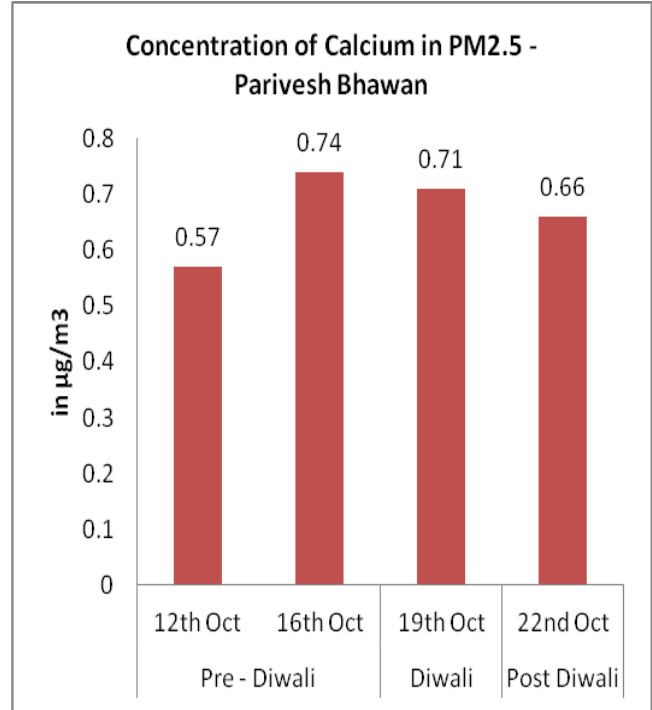


Figure 29b

In case of Calcium, it can be seen there is reduction in the quantum of Calcium in both the areas i.e. Pitampura and Parivesh Bhawan during the day of Diwali. It was $0.76\mu\text{g}/\text{m}^3$ and $0.71\mu\text{g}/\text{m}^3$ respectively for Pitampura and Parivesh Bhawan on 19 October, 2017 (Diwali Day).

e) Titanium

Titanium is responsible for coughing, and difficulty in breathing. It may cause skin and eyes irritation.

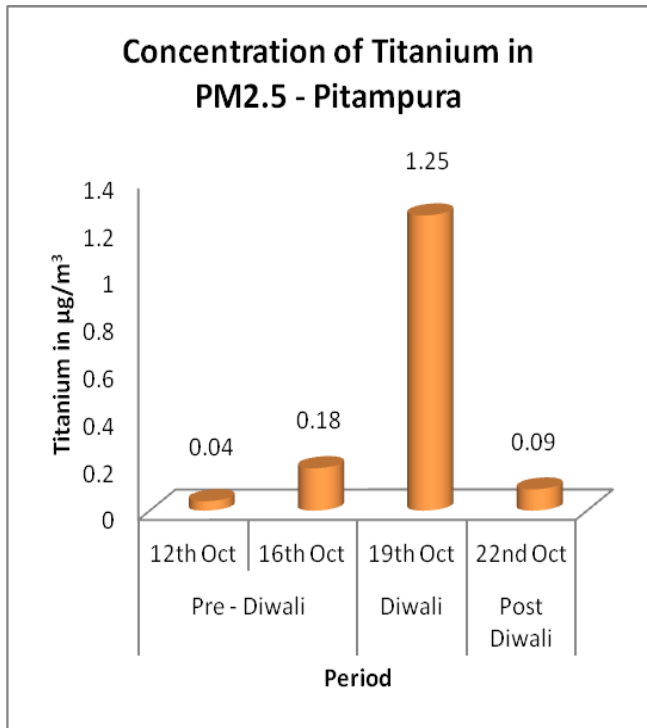


Figure 30a

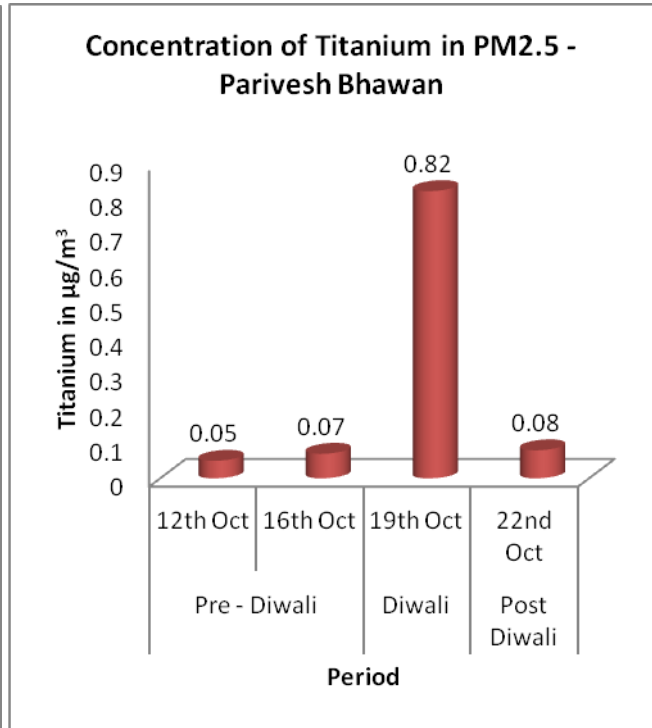


Figure 30b

In both the areas viz., Pitampura and Parivesh Bhawan, concentration of Titanium in PM_{2.5} during Diwali, 2017 is high as compared to other days i.e. before and after Diwali. It was recorded 1.25 $\mu\text{g}/\text{m}^3$ and 0.82 $\mu\text{g}/\text{m}^3$ for Pitampura and Parivesh Bhawan respectively on 19 October, 2017.

f) Iron

Exposure to Iron cause benign pneumoconiosis.

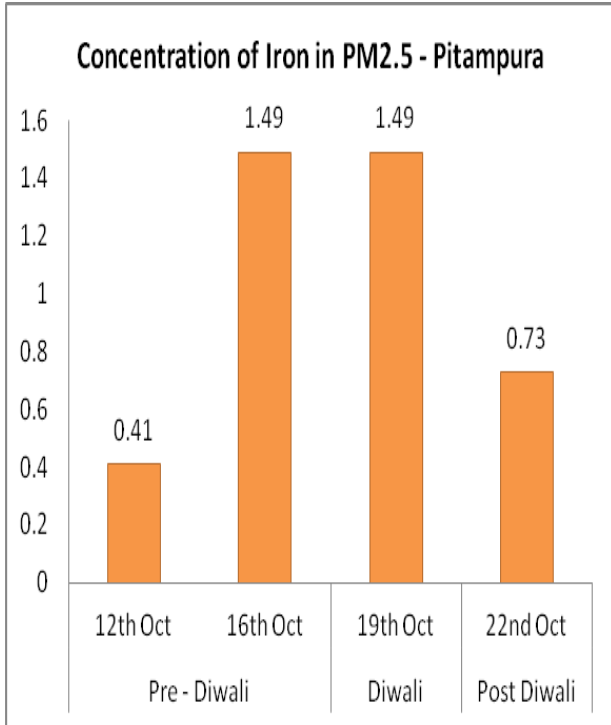


Figure 31a

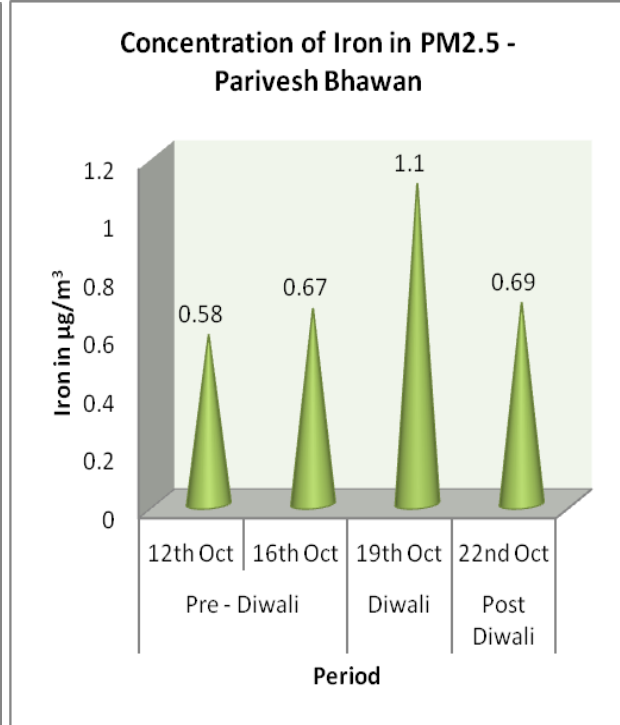


Figure 31b

From Figure 31a it can be observed that the quantum of Iron was same as before Diwali and during diwali in the area of Pitampura, which is $1.49 \mu\text{g}/\text{m}^3$, whereas it has been decreased to $0.73 \mu\text{g}/\text{m}^3$ after Diwali. In the area of Parivesh Bhawan, it has been risen on the day of Diwali to $1.1 \mu\text{g}/\text{m}^3$ and then dropped to $0.69 \mu\text{g}/\text{m}^3$ after diwali 2017.

g) Copper

Long-term exposure to copper dust can irritate your nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea

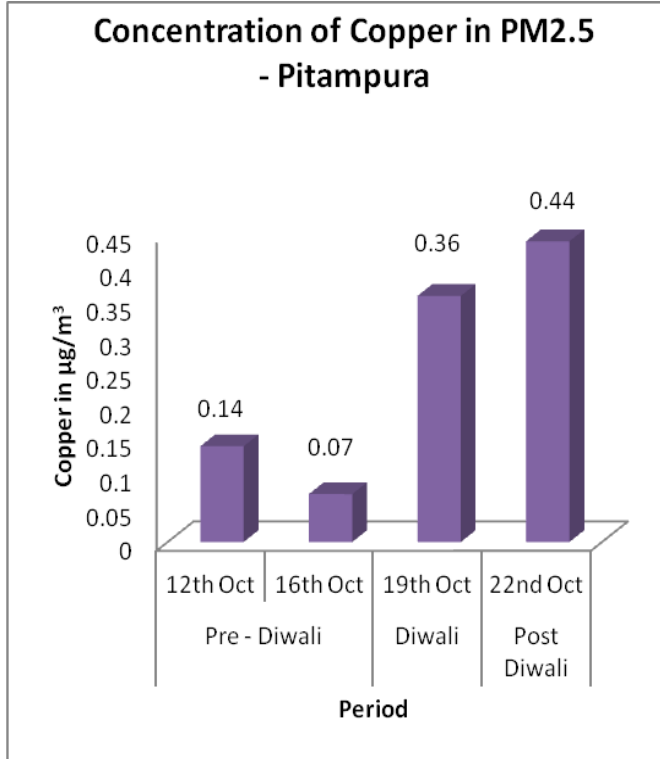


Figure 32a

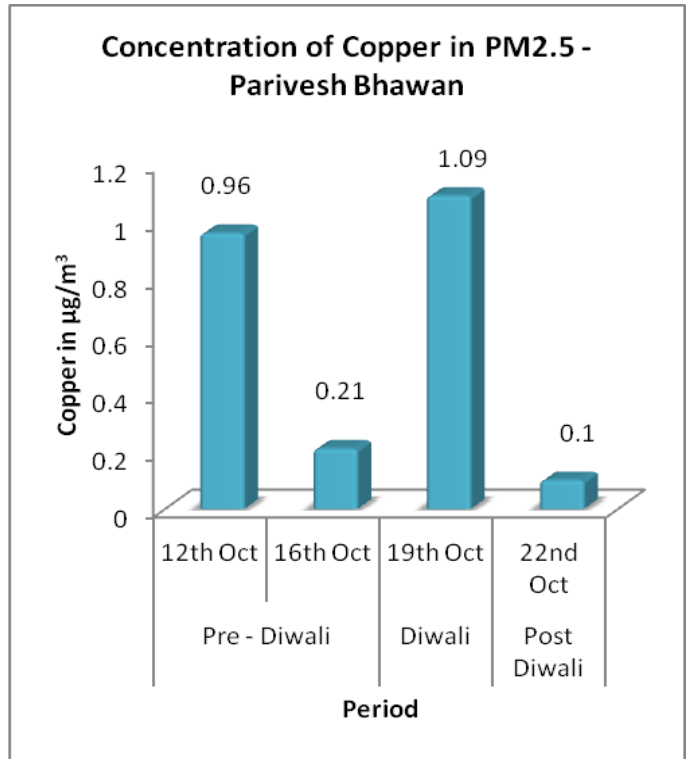


Figure 32b

In figure 32a, concentration of copper in PM_{2.5} in the area of Pitampura has risen on Diwali day to 0.36 $\mu\text{g}/\text{m}^3$ as compared to pre – diwali days and then marginally increased to 0.44 $\mu\text{g}/\text{m}^3$ after diwali. Whereas, in case of Parivesh Bhawan (in figure 32b), it can be seen that value of Copper has reduced to 0.1 $\mu\text{g}/\text{m}^3$ after increasing to 1.09 $\mu\text{g}/\text{m}^3$ on diwali day i.e. 19 October, 2017.

h) Zinc

Inhaling large amounts of zinc can cause a specific short-term disease called metal fume fever.

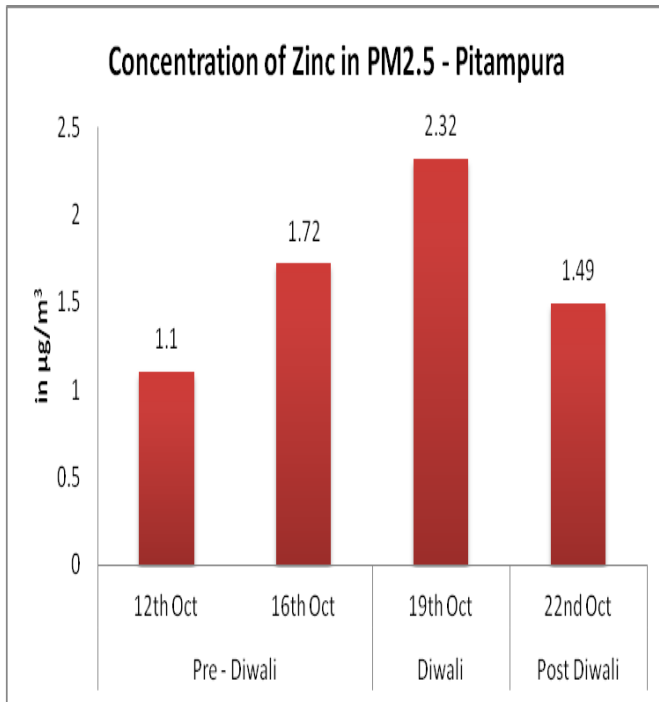


Figure 33a

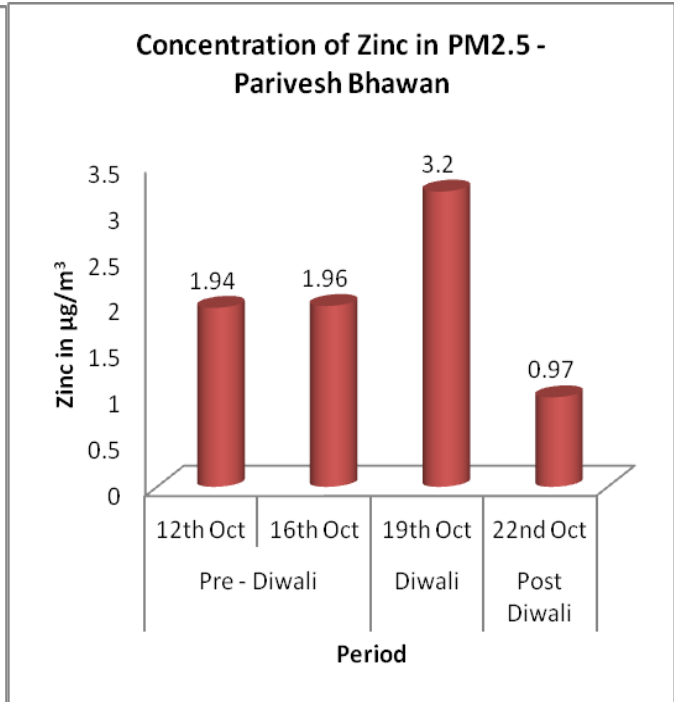


Figure 33b

It can be seen from above figures that the concentration of Zinc was as high as $2.32 \mu\text{g}/\text{m}^3$ on the day of Diwali as compared to pre and post festival days in Pitampura. Same scenario can be seen for Parivesh Bhawan during Diwali day, when value of sulfur is monitored at $3.2 \mu\text{g}/\text{m}^3$ as compared to before and after Diwali period.

i) Strontium

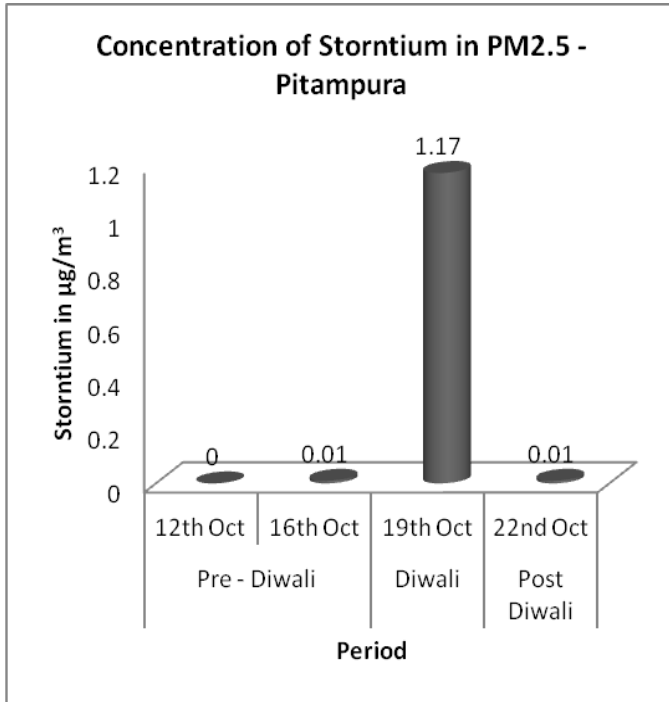


Figure 34a

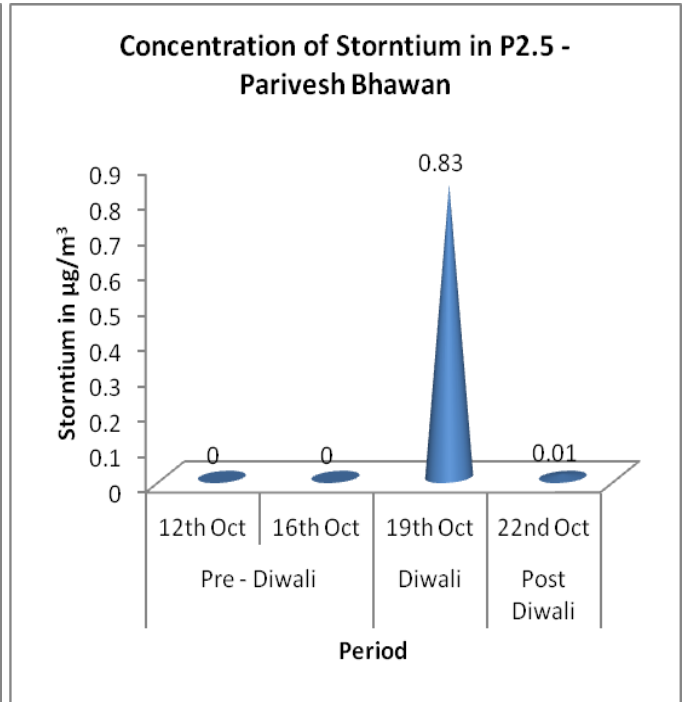


Figure 34b

On Diwali day, value of Strontium in $\text{PM}_{2.5}$ was $1.17 \mu\text{g}/\text{m}^3$ as compared to days before and after festival in Pitampura area. In Parivesh Bhawan area too, it has touched point of $0.83 \mu\text{g}/\text{m}^3$, which is as high in contrast to the period of pre and post Diwali.

j) Antimony

Antimony in the air can effects lung. It can also cause heart problems and eye irritation.

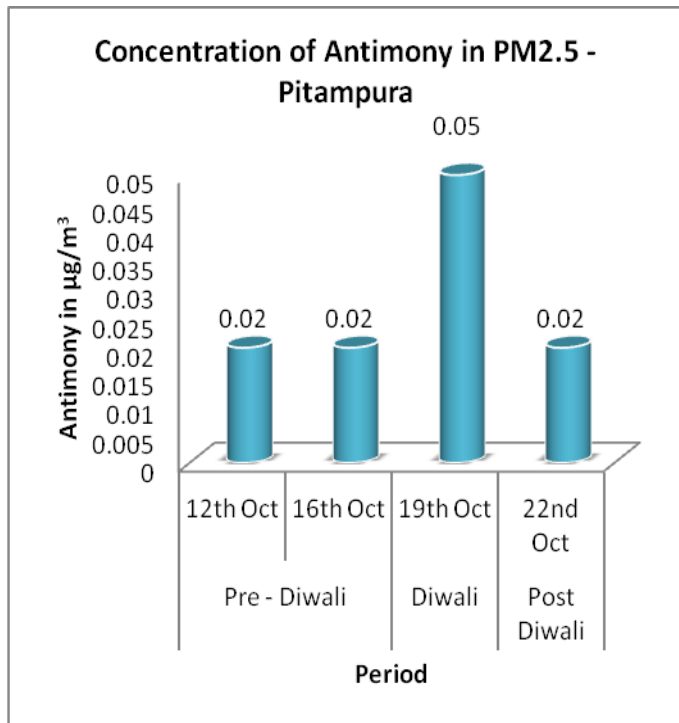


Figure 35a

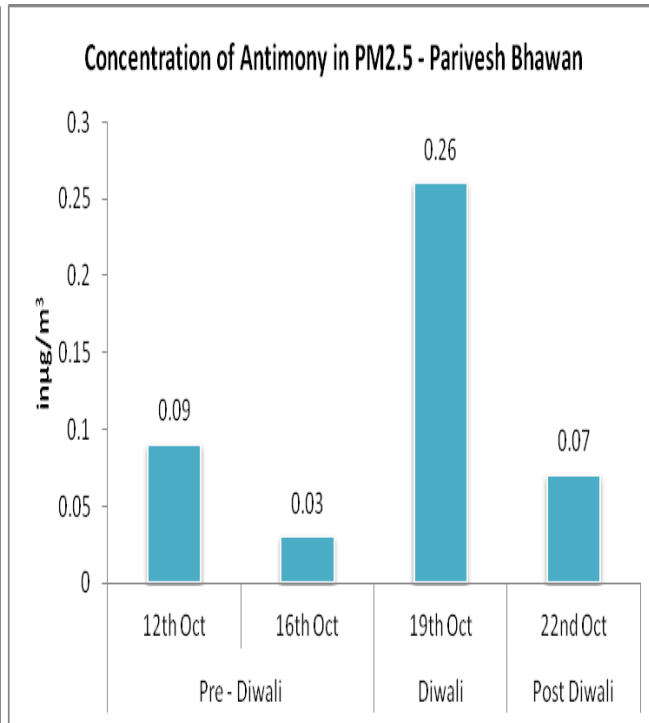


Figure 35b

As per above figures, it can be seen there is increase in the quantum of Antimony in both the areas i.e. Pitampura and Parivesh Bhawan during the day of Diwali. It was $0.05\mu\text{g}/\text{m}^3$ and $0.26\mu\text{g}/\text{m}^3$ respectively for Pitampura and Parivesh Bhawan on 19 October, 2017 (Diwali Day).

k) Barium

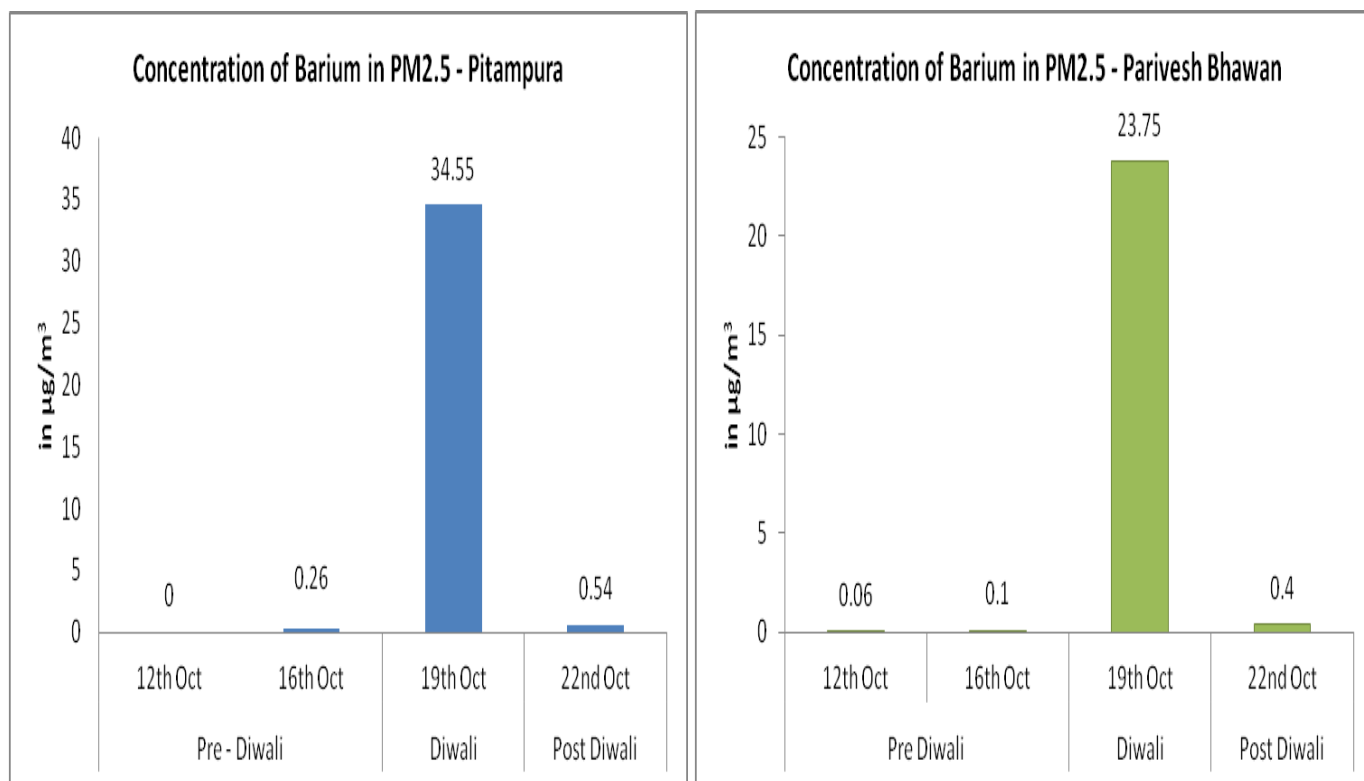


Figure 36a

Figure 36b

In both the areas viz., Pitampura and Parivesh Bhawan, concentration of Barium in PM_{2.5} during Diwali, 2017 is high as compared to other days i.e. before and after Diwali. It was recorded 34.55 µg/m³ and 2.75 µg/m³ for Pitampura and Parivesh Bhawan respectively on 19 October, 2017.

4. METROLOGICAL DATA

Table 40: CPCB DELHI AIR LABORATORY

Comparison of Meteorological Parameters 01st Sept to 30th Sept 2017

Dates	Temperature (°C)	Relative Humidity(%)	Mixing Height (m)	Wind Speed (m/sec)
1-Sep	30.05	72.89	395	1.09
2-Sep	29.36	73.28	443	1.02
3-Sep	31.72	59.01	510	1.01
4-Sep	32.46	45.22	631	1.03
5-Sep	32.71	42.12	608	1.03
6-Sep	31.98	43.52	700	1.01
7-Sep	30.56	65.47	520	0.97
8-Sep	32.63	45.21	546	0.95
9-Sep	33.08	43.58	575	1.03
10-Sep	34.16	37.28	547	0.96
11-Sep	33.43	69.28	555	1.01
12-Sep	33.63	83.68	520	0.99
13-Sep	33.90	83.01	533	0.98
14-Sep	33.90	83.01	574	0.95
15-Sep	33.96	62.28	674	1
16-Sep	31.73	88.31	549	0.98
17-Sep	32.20	79.18	787	0.99
18-Sep	33.08	64.58	796	1.04
19-Sep	33.22	58.27	684	0.93
20-Sep	30.05	72.89	725	0.91
21-Sep	32.31	76.55	715	1.01
22-Sep	27.34	97.28		0.99
23-Sep	26.90	96.66	542	1
24-Sep	29.33	74.31	603	1.02
25-Sep	31.99	50.00	690	0.98
26-Sep	31.57	51.42	617	1.02
27-Sep	31.57	51.42	644	0.88

28-Sep	32.12	75.12	618	0.92
29-Sep	32.38	84.36	686	0.98
30-Sep	32.06	69.43	723	1
Max	34.2	97.3	796.0	1.1
Min	26.9	37.3	395.0	0.9
Average	31.8	66.6	610.7	1.0

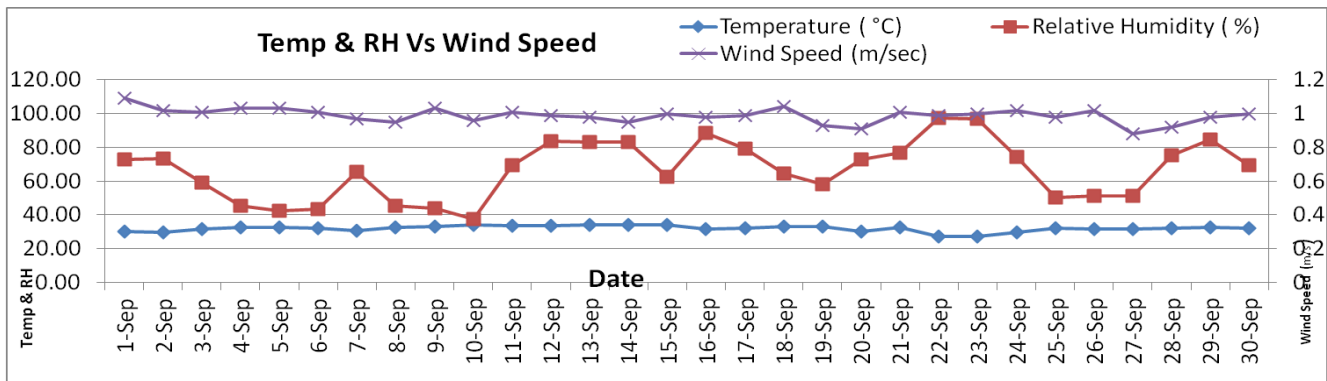


Figure 37

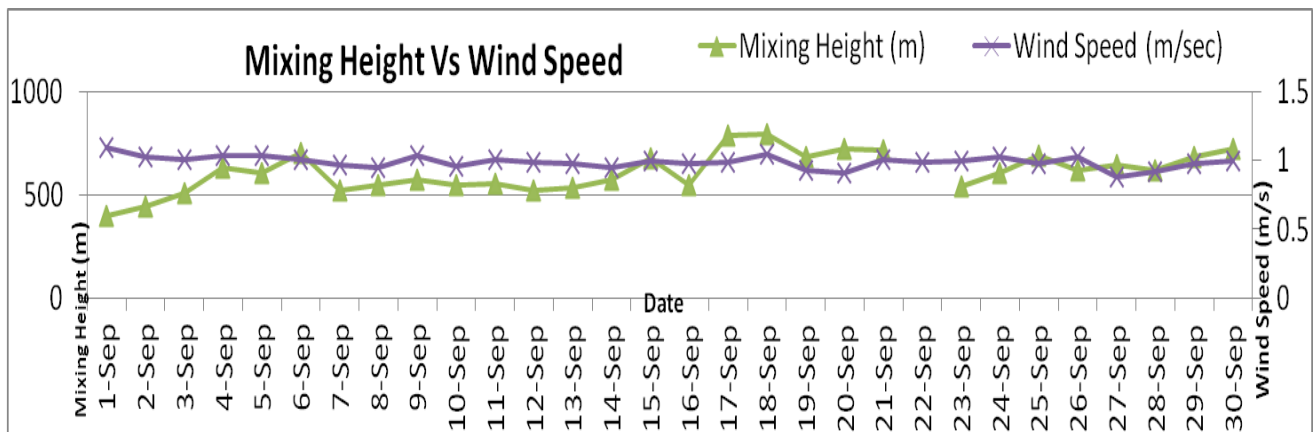


Figure 38

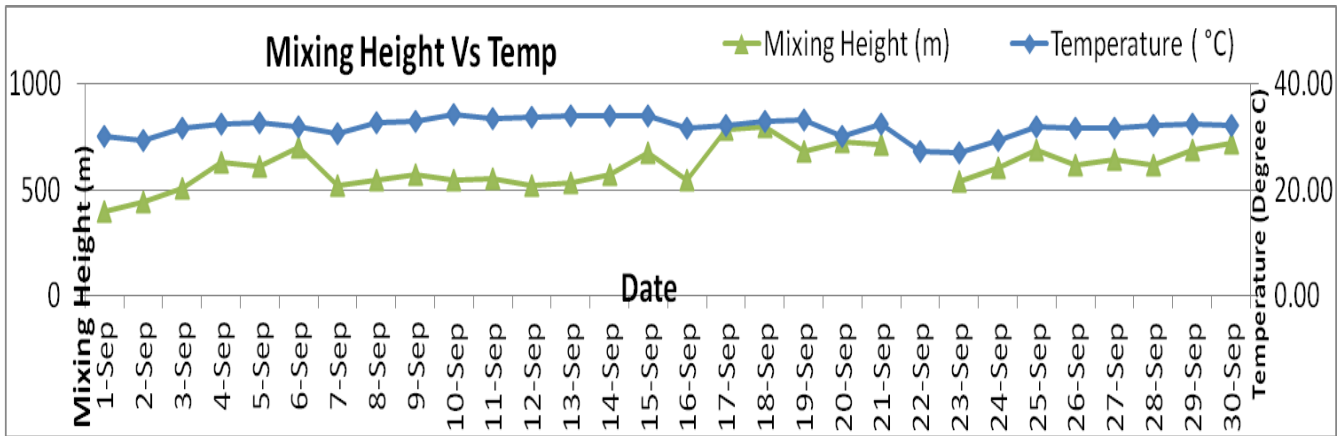


Figure 38

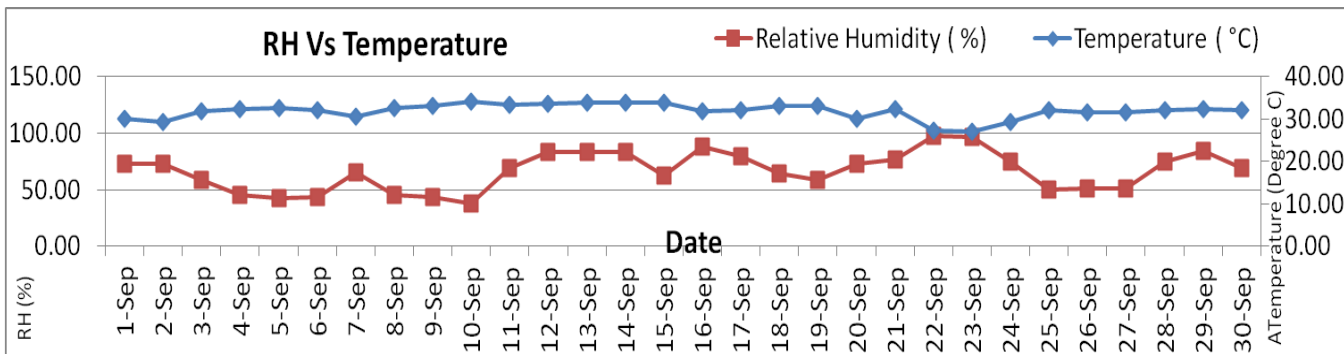


Figure 39

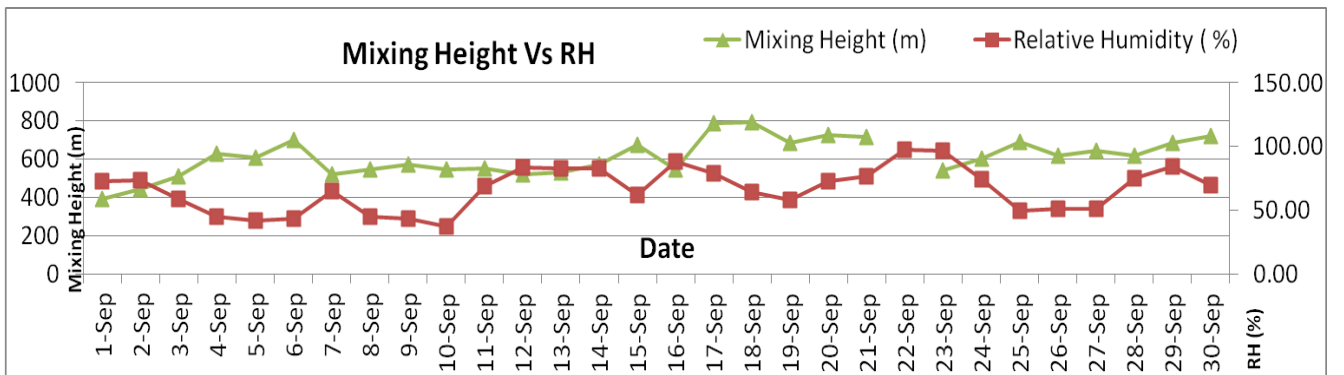


Figure 40

Table 41: CPCB DELHI AIR LABORATORY

Comparison of Meteorological Parameters 01st Oct to 31st Oct 2017

Dates	Temperature (°C)	Relative Humidity (%)	Mixing Height (m)	Wind Speed (m/sec)
1-Oct	31.15	60.68	668	0.99
2-Oct	32.19	50.23	691	0.99
3-Oct	31.19	61.59	742	1.02
4-Oct	32.53	69.79	719	1.03
5-Oct	32.53	65.49	748	1.03
6-Oct	31.66	37.33	693	1.03
7-Oct	32.01	50.11	740	1.01
8-Oct	30.88	76.92	595	0.95
9-Oct	32.52	43.9	527	0.72
10-Oct	30.14	53.6	587	0.76
11-Oct	30.76	55.29	557	0.64
12-Oct	31.57	44.9	615	0.72
13-Oct	30.6	42.08	548	0.74
14-Oct	30.71	48.4	641	0.7
15-Oct	30.39	37.94	562	0.68
16-Oct	31	35.2	623	0.7
17-Oct	29.7	41.8	633	0.7
18-Oct	29.3	44.9	547	0.7
19-Oct	29.9	45.6	481	0.5
20-Oct	29.4	47.7	484	0.6
21-Oct	28.9	41.7	569	0.6
22-Oct	29.5	40.3	462	0.4
23-Oct	28.5	48.7	453	0.6
24-Oct	27.7	42.8	559	2.2
25-Oct	26.8	45.3	476	1.5
26-Oct	26.5	51.0	553	1.5
27-Oct	26.1	52.7	493	1.4
28-Oct	26.2	51	570	1.5
29-Oct	24.5	60.8	551	1.3
30-Oct	25.4	58.7	522	1.2
31-Oct	24.8	61.9	470	1.3
Max	32.5	76.9	748	1.5
Min	28.5	35.2	453	0.4
Average	30.7	50.2	597	0.80

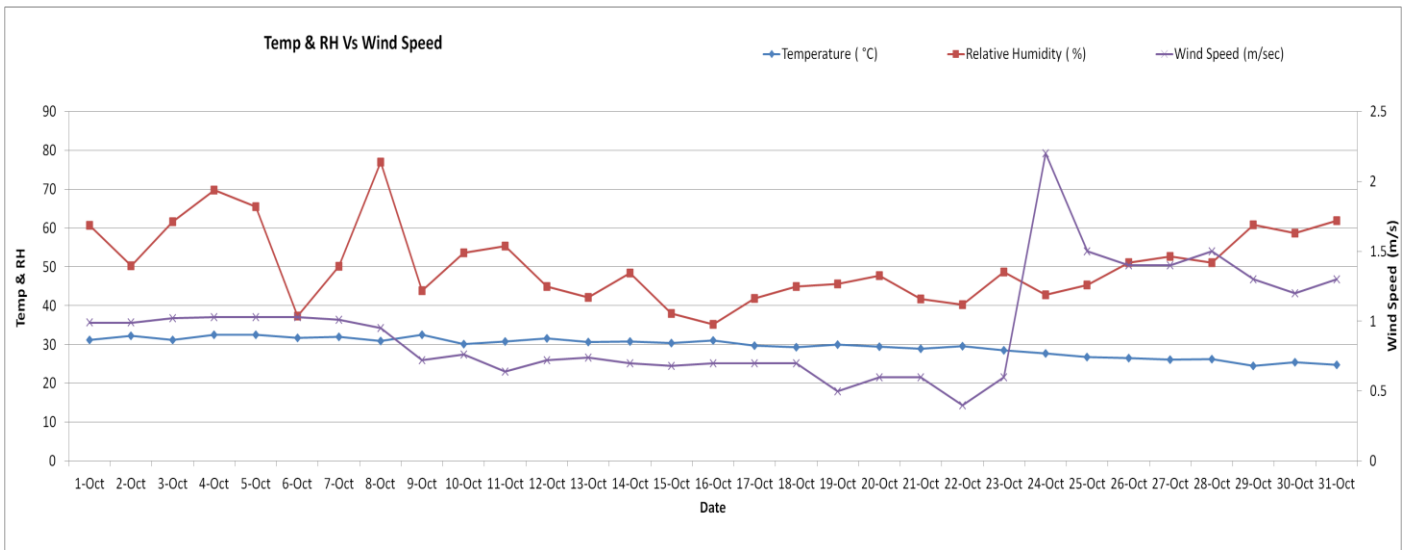


Figure 41

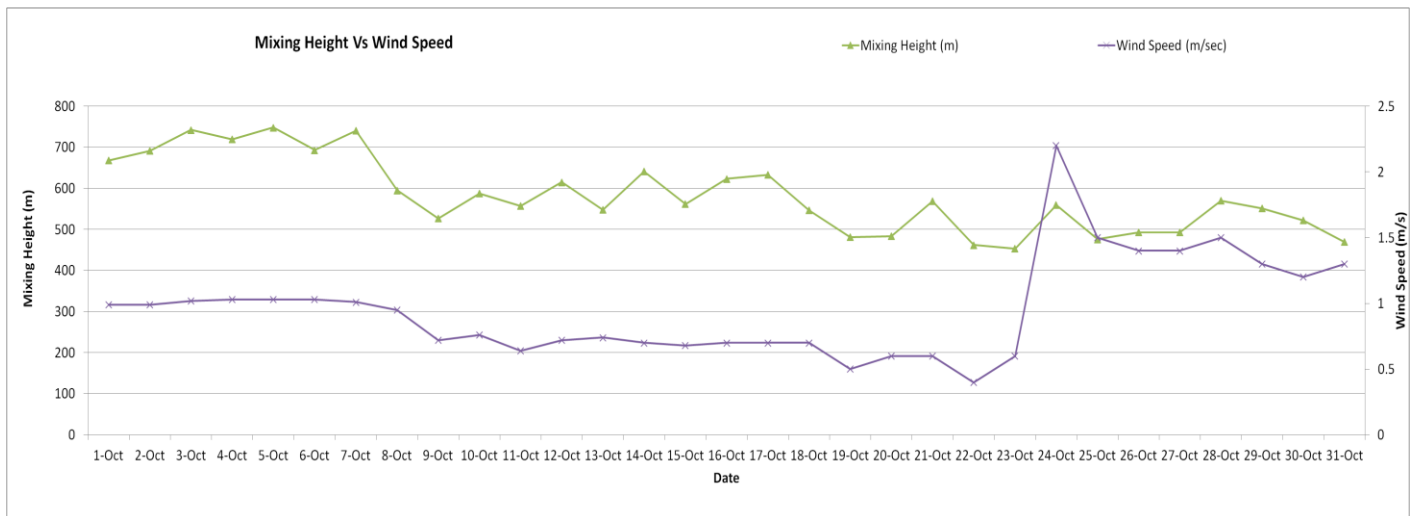


Figure 42

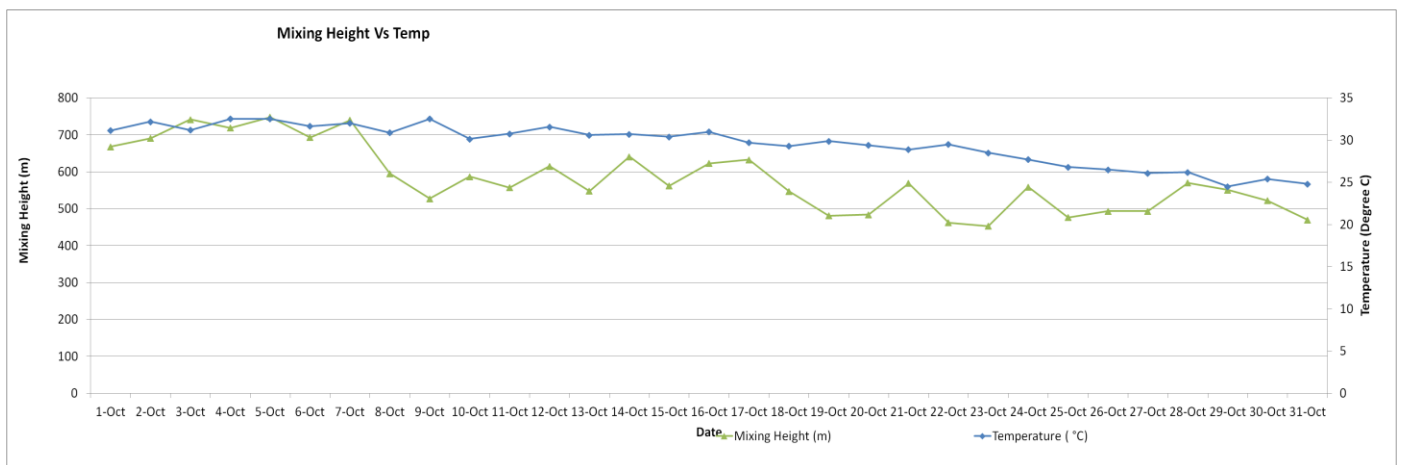


Figure 43

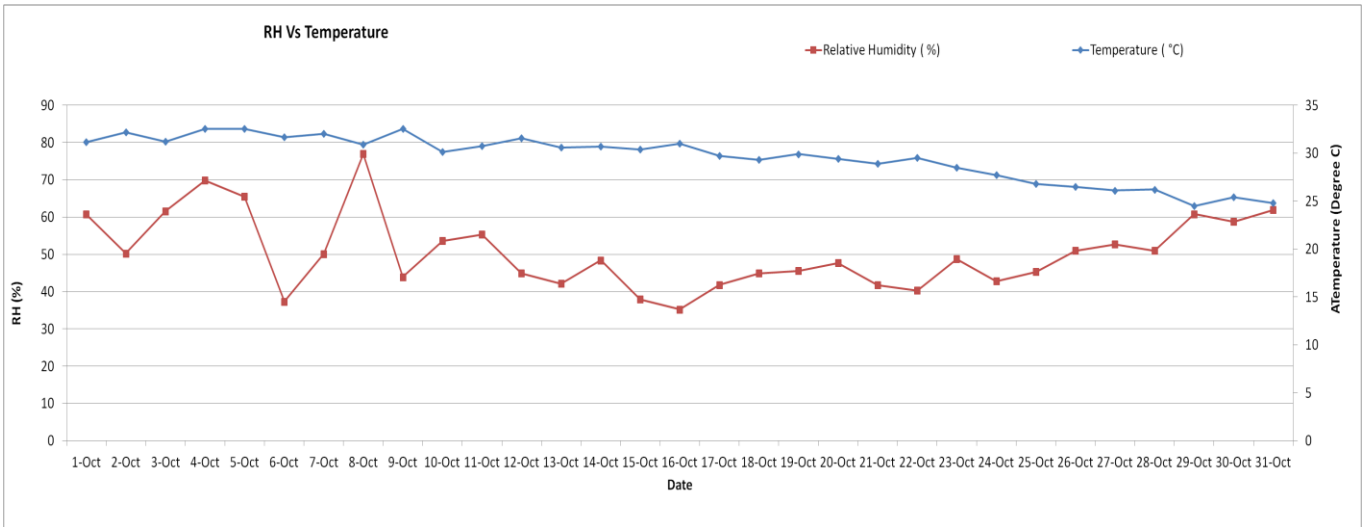


Figure 44

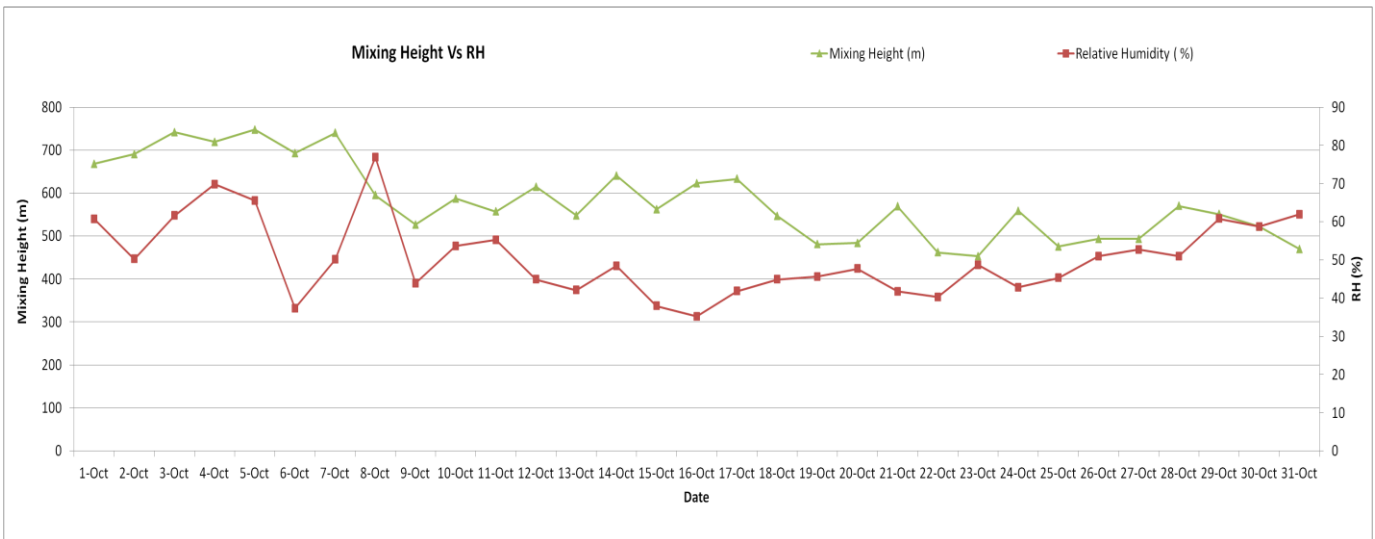


Figure 45

5. SUMMARY

The present study looked into impact of fire crackers bursting on ambient air quality data and health of population in Delhi during Dusshera and Diwali. Four areas in different zones of Delhi namely Pitampura, Parivesh Bhawan, Sirifort and Kotla were chosen.

All subjects were interviewed on a pre-designed questionnaire before and after Dusshera and Diwali. The questionnaire included data on any health related matter including symptoms and signs. The subjects for Pre and post exposure interview and examination were same. There was less than 5% drop out rate.

Additionally on site spirometry to assess lung function was done pre and post Diwali in a subset of these subjects. Hospital patient data during this period was also collected to ascertain any significant change in patient number post exposure.

A small number of subjects also underwent estimation of metals in their urine.

The analysis of data revealed following findings:

- The respiratory system related symptoms and signs were not much different pre and post dusshera and during Diwali. Although there was some increase in cough and breathlessness. But this did not translate into any significant illness requiring immediate medical attention.
- Other system related complaints were also not much different pre and post dusshera and during Diwali.
- Most of the subjects in the areas surveyed felt that environment was noisy during the day of Diwali and felt uncomfortable and few of them were not able to concentrate post - diwali.
- Although there were no significant complaints of difficult in hearing or need to speak louder or understand the conversation post - diwali.

- There were excessive watering from eyes, redness and burning sensation post – diwali in some areas
- Few cases were observed of itching following firecrackers bursting but no significant skin spots or issues with the hair dryness or itching post - diwali.
- Hospital data showed some increase in post dusshera hospital visit and admission in some hospitals but the number was not significant statistically when data available from all hospitals were analyzed in a group.
- Diwali data also reveals similar findings with non – significant increase in admission related to respiratory and cardiac diseases and stroke. We need to have more data from hospitals as only few hospitals have provided the requisite information. However, air pollution was high during this period throughout Delhi and hence increase in admissions partly may be related to it in few hospitals. The need to study for longer period the impact of fire cracker bursting for many years continuously can throw the correct picture.
- There was evidence of increased values of barium and strontium in urine samples of many subjects. These are some of the metals used in fire cracker manufacturing. Increased levels in urine do reflect a probability of exposure. However, all other elements are not increased to substantiate the effect of bursting of fire crackers. It is also possible that the individuals were exposed due to bursting of fire crackers directly or indirectly in their locality.
- Increased levels of some of these metals were also recorded in CPCB Ambient air quality data during Diwali
- Deterioration in air quality was observed during Diwali day whereas it improved post - diwali as per the ambient air quality data provided by the Central Pollution Control Board.
- Concentration of most of the elements in PM_{2.5} were reportedly increased during the day of Diwali except Calcium as per the information provided by CPCB.
- There was lot of media and newspaper information for public awareness on fire cracker contributing to air pollution.
- The restriction in use of fire crackers due to Hon'ble Supreme Court ban on sale also led to less bursting this season in Delhi.

- There was less worsening of ambient air quality this time in comparison to last year as is reflected in CPCB data.
- The period of Dussehra and Diwali came much earlier compared to last year and stubble burning was much later this time which probably resulted in less deterioration in air quality.
- However, the study involving larger population in some more areas and collection of data from a large number of hospitals may provide more information to find the immediate impact on health due to bursting of fire crackers worsening the air quality. It is also essential to study this impact for few years continuously by keeping the same population cohort under observation to see long term impact.
- Air quality did worsen during Diwali and symptoms of eye, increased coughing, relatively more hospital visits, increased noise levels and high metal levels in urine do reflect adverse impact of fire cracker bursting. However, it was statistically not significant.

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ANNEXURE - I

QUESTIONNAIRE REGARDING MEDICAL EXAMINATION PRE -DUSHERA

1. Name: _____ 2. Age: _____ 3. Sex: M/F
4. Occupation _____ 5. Address: _____ 6. Contact No. _____

MEDICAL BACKGROUND:

7. Are you suffering from any illness Y/N

7A. If yes, please specify:

8. Do you have:

- a) Cough Y/N
b) Sputum Y/N
c) Breathlessness Y/N
d) Chest - pain Y/N
e) Weakness in any part of body Y/N

9. Any History of prolonged illness in past Y/N

10. Treatment History: Y/N

Are you taking any drug?, If so, specify

11. Personal History:

- a) Smoking Y/N
b) Alcohol Y/N
c) Tobacco: Y/N

12. Are you having any illness Y/N

13. **Any Investigation Report:** _____

18. Other Symptoms:
- Are you having fever Y/N
 - Are you feeling fatigue and lethargy Y/N
 - Do you have lack of concentration Y/N
 - Early Fatigue Y/N

OTHER PROBLEMS

20. Do you think environment was noisy on Dusshera day Y/N
21. Did it affect your hearing? Y / N / do not know
22. Were you suffering from any hearing disease earlier? Yes/No
23. Difficulty in hearing, if yes Y/N
- A Which ear(s) R/L/Both
 - B Since when -----
 - C Is it increasing / decreasing /same
 - D Have you consulted doctor for this Y/N
24. Did you have any skin problems, if so specify_____ Y/N
25. Any Other Problem? _____

ANNEXURE – III

QUESTIONNAIRE REGARDING MEDICAL EXAMINATION PRE –DIWALI

1. Name: _____ 2. Age: _____ 3. Sex: M/F
4. Occupation _____ 5. Address: _____ 6. Contact No. _____

MEDICAL BACKGROUND:

7. Are you suffering from any illness Y/N

7A. If yes, please specify:

8. Do you have:

- f) Cough Y/N
g) Sputum Y/N
h) Breathlessness Y/N
i) Chest - pain Y/N
j) Weakness in any part of body Y/N

9. Any History of prolonged illness in past Y/N

10. Treatment History: Y/N

Are you taking any drug?, If so, specify

11. Personal History:

- d) Smoking Y/N
e) Alcohol Y/N
f) Tobacco: Y/N

12. Examination:

Pulse: _____ B.P. _____ R.R. _____ Pallor: _____ Icterus: _____

Cyanosis:___Clubbing:___Pedal _____

Edema_____Lymphadenopathy_____

13. Systemic Examination:

Chest:_____CVS:_____

Any Other:_____

14. Spirometry:

- FEV1:_____FVC:_____FEV1/FVC Ratio:_____Others:_____

15. Any Investigation Report:_____

15. Spirometry:
- FEV1: _____
 - FVC: _____
 - FEV1/FVC Ratio: _____
 - Others: _____

EAR PROBLEMS

16. Do you think environment was noisy on Diwali day Y/N
17. If noisy? Are you comfortable with existing level of noise Y / N / do not know
18. Have you developed any complaint of ear (on or after Diwali day): Yes/No
- Ringing Yes/No
 - Hearing Yes/No
 - Which Ear R/L/Both
 - Is it Increasing/Decreasing/Same
19. Were you suffering with any disease of the ear earlier, if yes Y/N
20. Are you raising the volume of T.V. since Diwali: Y/N
21. Are you asking people to speak louder since Diwali day: Y/N
22. Do you have any difficulty in understanding any conversation/words over the phone: Y/N
23. Are you getting headache since then Y/N
24. Has your blood pressure risen since Diwali Y/N/Don't know

SKIN PROBLEMS

25. Did you have a burn due to the crackers, oil or wax? Y/N
- 25 A. Was it due to Oil/ cracker/ Electric

- | | | |
|------|---|----------------------------------|
| 26. | While handling the crackers did you have any itching on the hand, feet, fingers or face | Y/N |
| 26A. | Was it due to | Oil/ diya/ colors used/ crackers |
| 27. | Did you have any problem with your hair (dryness, itching) after or during Diwali | Y/N |
| 28. | After Diwali did you notice any small black spots on the skin (tattoo) | Y/N |

EYE PROBLEMS

- | | | |
|-----|---|--|
| 29. | After Diwali night did you notice any redness in your eyes. | Y/N |
| 30. | After Diwali night did you notice any swelling in your eyes | Y/N |
| 31. | After Diwali night did you notice any burning in your eyes. | Y/N |
| 32. | Were you treated for burning of eyes at any time in the last 1 month | Y/N |
| 33. | After Diwali night did you notice any watering from your eyes? | Y/N |
| 34. | Do you suffer from frequent watering from your eyes? | Y/N |
| 35. | After Diwali night did you notice any blurring of vision in your eyes? | Y/N |
| 36. | Did you have problems in watching television or reading after burning firecrackers/ or watching people burn them? | Y/N |
| 37. | Did you suffer from any injury/burns during Diwali, if yes specify_____ | Y/N |
| 38. | What do you feel about the idea of bursting fire-crackers?
a. Is sign of celebration and must not be stopped? | Choose any one option from left and write answer in this space |

b. Celebration ok, but do with lights?

c. Firecrackers in moderation and in public open spaces,
community participation?

39. How many hours you stay indoor and outdoor?

ANNEXURE - V

CASES ADMITTED TO HOSPITALS

Adults: Cardiac and Cerebral conditions

S.No.	Cause of admission	Age group						Total	Deaths
		20-45		46-65		Above 65			
		M	F	M	F	M	F		
1.	Angina pectoris								
2.	Ventricular arrhythmia								
3.	Myocardial infraction								
4.	Cerebro vascular accidents (Stroke)								

Adults: Respiratory Conditions

S.No.	Cause of admission	Age group						Total	Deaths
		20-45		46-65		Above 65			
		M	F	M	F	M	F		
5.	COPD								
6.	Asthma Exacerbation								
7.	Any Other e.g. Pneumonia etc.								

Adolescents and children: Respiratory conditions

S.No.	Cause of admission	Age group				Total	Deaths
		0-9		10-19			
		M	F	M	F		
8	Respiratory tract infection						
9	Asthma Exacerbation						

Adults and Children: Burns

S.No.	Cause of admission	Age group										Total	Deaths	
		0-9		10-19		20-45		46-65		Above 65				
		M	F	M	F	M	F	M	F	M	F			
10	Skin burns													
11	Eye Burns													

ANNEXURE - VI

Table 2: Ambient air Quality during Diwali days 2017

	ITO	PP	JP	PB	ITO	PP	JP	PB	ITO	PP	JP	PB
	12.10.2017 (One week before Diwali)				19.10.2017 (On Diwali Day)				22.10.2017 (3 days after Diwali)			
SO ₂	7	13	6	13	11	28	43	70	15	11	7	38
NO ₂	87	73	62	66	74	61	73	47	80	66	82	61
PM ₁₀	208	226	193	272	438	690	706	628	245	324	523	296
PM _{2.5}	132	147	109	158	180	677	638	496	192	161	134	167
<i>PP = Pitampura; JP = Janakpuri; PB = Parivesh Bhawan, ITO PM_{2.5} data are online</i> Data for Sirifort area is not available												

Table 2(a): Online Ambient Noise Level data during Pre-Deepawali (2014-2017)

S. No.	Monitoring Stations	Pre-Deepawali Day								Standards	
		15.10.2014		05.11.2015		24.10.2016		12.10.2017		Day Time	Night Time
		Day Time	Night Time	Day Time	Night Time	Day Time	Night Time	Day Time	Night Time		
1	Anand Vihar (C)	-	-	68	63	66	62	68↑	64↑	65	55
2	Punjabi Bagh (R)	-	-	60	55	59	49	60↑	59↑	55	45
3	CPCB HQ (C)	66	53	67	57	66	57	66=	56↓	65	55
4	Civil Lines (C)	-	-	62	60	61	59	61=	57↓	65	55
5	DCE, Bawana (S)	53	46	77	80	54	50	55↑	50=	50	40
6	Dilshad Garden(S)	50	45	53	48	54	49	53↓	53↑	50	40
7	ITO (C)	73	69	74	68	71	66	73↑	68↑	65	55
8	Mandir Marg (S)	-	-	60	46	60	45	55↓	46↑	50	40
9	NSIT, Dwarka (S)	55	55	56	52	57	53	57=	54↑	50	40
10	R.K. Puram (S)	-	-	63	52	61	51	60↓	52↑	50	40

Note : All values are in Leq dB(A)

Table 2(b): Online Ambient Noise Level data during **Deepawali Days (2014-2017)**

S.No.	Monitoring Stations	Deepawali Day								Standards	
		23.10.2014		11.11.2015		30.10.2016		19.10.2017		Day Time	Night Time
		Day Time	Night Time	Day Time	Night Time	Day Time	Night Time	Day Time	Night Time		
1	Anand Vihar (C)	-	-	69	70	68	68	68=	68=	65	55
2	Punjabi Bagh (R)	-	-	66	71	60	58	56↓	54↓	55	45
3	CPCB HQ (C)	69	69	67	68	64	61	64=	59↓	65	55
4	Civil Lines (C)	-	-	64	66	61	62	59↓	60↓	65	55
5	DCE, Bawana (S)	60	63	66	71	56	55	53↓	52↓	50	40
6	Dilshad Garden (S)	65	67	65	67	57	55	53↓	53↓	50	40
7	ITO (C)	79	75	73	70	70	67	71↑	68↑	65	55
8	Mandir Marg (S)	-	-	60	60	54	51	51↓	48↓	50	40
9	NSIT, Dwarka (S)	63	63	63	62	58	57	57↓	57=	50	40
10	R.K. Puram (S)	-	-	67	65	61	57	59↓	53↓	50	40

Note : All values are in Leq dB(A)

ANNEXURE - VII

NOISE LEVELS DUE TO BURSTING OF FIREWORKS DURING DUSSEHARA AND DIWALI*

SUMMARY

‘C’ weighted peak level and ‘A’ weighted maximum level (LAImax) of impulse noise generated from bursting of fireworks during the festivities of Dusshera and Diwali were measured in different locations and conditions for the assessment of auditory risk to users of the fire crackers in light of the exposure conditions and the existing safety norms.

The sound level measurements during Dussehara were recorded/computed at the minimal safe permissible distance in the open ground where the effigies are positioned for kindling/igniting, while during Diwali festival the recordings were undertaken in the following exposure conditions of bursting of fireworks, viz.,

- a) over soft mud ground in the community/recreational parks with reflecting walls on all sides
- b) on hard cemented terrace/street with reflecting walls on both sides
and
- c) cover soft (kucha) ground existing in a typical village environment

Personal noise dose meters Type 4448 conforming to standards IEC 61252:2002 and ANSI SI.25:1991 and with peak measurement range of 95.0 to 143.3 dB (C) were used for undertaking the measurements at two time points, namely, three days prior to the event and on the day of the festival.

*Source: Defense Institute of Physiology and Allied Sciences (DIPAS), New Delhi

The peak sound pressure levels recorded at all selected localities (Dwarka, Rohini, Wazirabad and Timarpur) during Dussehara ranged from 131.8-153 dBC peak at the minimal standing permissible distance of 10 meters, while the peak sound levels recorded prior to the festival ranged from 75.6-101.2 dBC peak.

During Diwali, the peak sound pressure levels recorded during the firing of crackers on soft mud ground of the recreational parks with reflecting boundaries at locations of Dwarka Sector 3 and Anand Parbat were 139.8 dB and 143.5 dBC peak respectively, while on the terrace and narrow cemented road of Rohini Sectors 9 and 11, peak noise levels of 153.0 and 143.5 dBC peak respectively were observed at computed distance of 5 meters. At comparable distance of 5m, the bursting of crackers over soft soil in village environment at Ayodhya produced higher than 143.5dBC peak levels of impulses. The study showed mean max impulse 'A' weighted levels ranging from 102.7 – 122.1 dBAI and 'C' weighted peak pressure levels ranging from at 139.8 to more than 143.5 at 5 m distance.

The results of sound pressure levels in the different locations and conditions undertaken during Dussehara and Diwali are summarized in Table 1 & 2 respectively.

Table 1: Sound Pressure Levels prior to and during Dusshera 2017 (30/09/2017)

Locations	LCpeak (dB) during Dussehara	LCpeak (dB) computed at 10m	Prior to Dussehara LCpeak (dB)	Condition of bursting of fireworks
Dwarka, Sec-3	122.3 (30m)	131.8	76.0 – 97.8	Open expanse (no reflecting boundaries)
Dwarka, Sec-3	141.0 (30m)	150.6	76.0 – 97.8	
Rohini, Sec-9	140.1 (40m)	149.6	90.8 – 101.2	
Rohini, Sec-11	123.2 (80m)	132.7	75.6 – 97.9	
Wazirabad	143.5 (10m)	153.0	91.5 – 101.6	
Timarpur	143.5 (20m)	153.0	79.2 – 95.6	

Table 2 : Sound pressure levels prior to and during Diwali 2017 (19/10/2017)

DIWALI 2017 (19/10/2017)						
Locations	LCpeak (dB) during Diwali	LCpeak (dB) Computed at 10m	LCpeak (dB) Computed at 5m	LAI_{max} (dB 'A')	LCpeak (dB) Prior to Diwali	Condition of bursting of fireworks
Dwarka Sec-3	133.8 (10m)	133.8	139.8	102.7	76.0 – 97.8	Soft mud ground (18mX18m) with reflecting boundary
Anand Parbat	143.5 (5m)	137.5	143.5	112.6	80.1 – 98.3	Soft mud ground (10m X 4m) with reflecting boundary
Rohini Sec-9	143.5 (15m)	147.0	153.0	122.1	90.8 – 101.2	Cemented terrace (10m X 10m) with reflecting boundary
Rohini Sec-11	143.5 (5m)	137.5	143.5	120.1	75.6 – 97.9	Narrow cemented street (6m wide) with reflecting boundary
Ayodhya	>143.5 (5m)	>137.5	>143.5	118.2	72.9 – 85.1	Soft ground with no reflecting boundaries

ANNEXURE – VIII





ANNEXURE – IX

Detail of Methods adopted

S.No	Parameters	Method Reference	Range of detection		Method outline
			Minimum	Maximum	
			$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$	
01	PM ₁₀	IS 5180 (Part 23): 2006 / (RA 2012)	5	1000	Sampling by Cyclone based High Volume Sampler; Analysis Gravimetric
02	PM _{2.5}	CB/CL/SOP/AQ/11 Issue No. 01 2016	2	800	Sampling using Low Volume FRM sampler; Analysis Gravimetric
03	SO ₂	IS 5182 (Part 2): 2001 / (RA 2012)	4	1050	Improved West and Gaeke Method: SO ₂ is absorbed in Tetra Chloro Mercurate (TCM) solution and Spectrophotometrically analyzed after development of colour with PRA
04	NO ₂	IS 5182 (Part 6): 2001 / (RA 2012)	6	750	Modified Jacob and Hochheiser Method: NO ₂ is absorbed in Sodium Hydroxide Sodium Arsenite solution, Spectrophotometrically analyzed after development of colour (Azo-dye) with Sulphanylamide and NEDA
05	Elements / Metals	EPA Method IO 3.3			ED – XRF: Non destructive analysis in single run by Philips make instrument; Model :Epsilon 5
i	Al		0.041031	800	
ii	S		0.030325	800	
iii	Cl ₂		0.010756	800	
iv	K		0.001195	800	
v	Ca		0.001494	800	
vi	Ti		0.002091	800	
vii	Fe		0.004033	800	
viii	Cu		0.001793	800	
ix	Zn		0.002988	800	
x	Sr		0.00493	800	
xi	Sb		0.011503	800	
xii	Ba		0.021959	800	

INSTRUMENT USED TO MEASURE AMBIENT SOUND LEVEL

Sound Level Meter is an instrument designed to respond in approximately the same way as the human ear and to give objective, reproducible measurements of sound pressure level. Sound level meter consist of a microphone, a processing section and read-out unit. The microphone converts the sound signal to an equivalent electrical signal. There are many type of microphone like condenser microphone, electrets condenser, dynamic microphone, carbon microphone, piezoelectric microphone, fiber optic microphone, which is used for various purposes. The most suitable type of microphone for sound level meters is the condenser microphone, which combines precision with stability and reliability. The electrical signal produced by the microphone is quite small and so it is amplified by a preamplifier before being processed. Noise Monitoring System (NMS) is used for measuring real time noise since large number of stations can be managed easily using this technology. It comprises of microphone, data logger and mounting stand.