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AIR POLLUTION ASSESSMENT DURING THE FESTIVALS OF DIWALI AND BHOGI IN VISAKHAPATNAM CITY

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ABSTRACT

India is known for festivals and celebrations because of its different cultures and customs in different states. The celebrations are turning into a significant giver of air contamination. During festivals, we generateair, water, and noise pollution. Diwali and Bhogi are some of the festivals that make air pollution dominant. Every year in October / November, Diwali's is celebrated by burning firecrackers in India with great joy and passion. However, Bhogi is Pongal's first day and is celebrated in memory of cloud and rain gods. One tradition observed is the annual Bhogi Bonfire, when undesirable family units throw things into a firewood and cow-dung cakes fire. Owing to burning Firewood, plastics, and rubber tyres, this festive Bhogi tradition has generated big air pollution in recent years. This research focuses on the influences of Diwali fireworks and Bhogi bonfire emissions in Visakhapatnam City during 2018–2020 on air pollutants like PM, PM., SO, and NO. Trace pollutants are examined on days before, during, and after Diwali and Bhogi days to determine the effect of festivity on city environmental quality. These pollutants showed a significant increase during Diwali and Bhogi days and gradually decreased after the festival.

KEY WORDS : Bhogi, Bonfire, Diwali, Festivals, Firecrackers, Pollution

INTRODUCTION

India is the place for festivals and celebrations because of its various cultures and customs in its various states. Almost celebrating daily of the year, the Republic of India holds a lot more festivals than anyplace else within the world. Every celebration includes discrete events, some inviting the periods of the year, the- reap, the downpours, or the full moon. Some cherish religious events, the birthdays of supernatural entities, and holy people, and the New Year. In most parts of India, there are a variety of these festivals (GOI, 2020). We like to appreciate such a significant number of parts of celebrations like nourishment, dresses, and in particular, the merriment that accompanies them. The celebrations are turning into a significant giver of air contamination. While we are celebrating these festivals, we are wasting many things and adding many pollutants to the environment, which causes pollution. During festivals, we cause air, water, and noise pollution, and they have an enormous impact on our health and not to forget that the animals and birds also suffer because of our anthropogenic activities. Diwali and Bhogi are a few of the festivals which cause dominant concern for air pollution. Diwali, the festival of lights celebrated every year in October/November with great joy and passion throughout India. This festival had its origins in illuminating every dark corner, every street and every house. Later, the Diwali became famous for the Firing Crackers, which became a significant part of the celebrations. Crackers usually comprise of 75 percent Potassium nitrate, 15 percent charcoal, 10 percent sulfur, potassium, and trace elements that have a high environmental and human health impact (Kulshrestha, 2004). While Bhogi is Pongal's first day, and is celebrated in honor of the gods of

clouds and rains to provide plenty of harvest, bringing the land plenty and prosperity. Its history goes back to the age of the Sangam, since 200 B.C. By 300 A.D. One custom observed is the Bhogi Fire that takes place each year on the second seven days of January, when family units throw undesirable items into a fire of wood and cow-dung cakes. The relevance of the burning, which consumes firewood and farm disposal, is to stay warm during the previous winter lap. In recent years, this Bhogi festive tradition has created immense air pollution because of the burning of firewood, plastics, and rubber tires, as agricultural waste is not available in cities. As a result, it releases carbon dioxide and other obnoxious gasses into the atmosphere, resulting in irritation of the eyes, nose, throat, skin, and respiratory diseases besides many health hazards (ENVIS Centre, 2019). Since Diwali and Bhogi influence not just the human well-being and the environment, it likewise influences winged animals and creatures. For this reason, wecarried an effort to comprehend the nature of air with; individuals to PM, PM., SO, and NO air pollutants in the city of Visakhapatnam, focussed on one day prior, during the celebration and the post-celebration day.

IMPACT OF AIR POLLUTION DURING DIWALI AND BHOGI ON ENVIRONMENT AND HUMAN WELL-BEING

Diwali is one of the most popular festivals in India, with considerable excitement and immense love.Both on festival day (Diwali day) and even after Diwali (Post Diwali days), sizable amounts of crackers and sparklers are burned (Sinha, 2013). Fireworks/ Sparkles/ Crackers is a low-risk explosive comprising any material or system created for the formation of colored fire or flame, flash, noise impact, smoke impact (chemical or natural), or other mixed fire signals, fuses, missiles, shells, percussion caps, etc. They are also classified into different categories like noise emitting fireworks, colour or light-emitting fireworks, Display Fireworks (shodhganga, 2020). The crackers have substances, including aluminum (Al), barium (Ba), carbon dioxide, iron (Fe), potassium (K), manganese (Mn), sodium (Na), sulfur (S), strontium (Sr). (Y Wang, 2007). Burning firecrackers contribute, without adoubt, to an increase in air pollution.In India, 51% of emissions are triggered by industrial contamination, 27% by automobiles, 17% by crop fire, and 5% by Diwali fireworks (Service, 2019). The levels of ozone (O), sulfur dioxide (SO), nitrogen oxide (NO), particulate matter (PM and PM.), and black carbon and polyaromatic hydrocarbons have to be increased in the air when crackers are fired during Diwali (S.C. Barman, 2008). It is a known fact that air pollutants are high in many Indian cities during and post-Diwali days. As this paper focuses mostly on toxins such as PM, PM., SO, and NO, it addresses the effect of these contaminants on humans and the environment.In humans, these pollutants can cause severe damage to lungs, aggravation of pre-existing heart diseases, slow immune response, prone to viral function, damage DNA of the growing fetus, premature mortality (Ahluwalia, 2015). While on environment SO act as an important precursor to acid rain which corrodes paints, metal and causes injury or death of animals and plants, NO forms secondary pollutants such as peroxyacetyl nitrate and nitric acid; which suppresses plant growth, and deposition of particulate matter on the surface of green leaves reduces light penetration and blocking the opening of stomata thus interfering with the absorption of CO and release of O (Ion, 2011).

Moreover, each year during the Bhogi festival, people celebrate with Bhogi bonfire early in the morning during the second week of January. The following are usually used for the Bhogi bonfire: wood, plastic, and rubber tyres.The smoke created from wood-burning, contains over 100 diverse substances mixes, a considerable lot of which is destructive and conceivably cancer-causing. Wood smoke toxins incorporate fine particulates, nitrogen oxides, sulfur oxides, carbon monoxide, unpredictable natural mixes, dioxins, and furans. Air with smoke from wood may cause severe problems of respiration and metabolic health. The risk of timber smoke is most considerable for children, pregnant women, the elderly, and those with allergies, asthma, bronchitis, emphysema, pneumonia, or other cardiac diseases (New Hampshire, 2019). At the same time, Open plastics burning emanate enormous volumes of toxic pollutants like fine particulate matter and the black carbon, which is responsible for climate change, and health. The most common toxic chemicals that occur when combustion of plastic wastes are polychlorinated biphenyls, polycyclic aromatic hydrocarbons (PAHs), dioxins and furans; chronic exposure lead to cancer and interferes with hormonal function (Carisse Hamlet, 2018). Anopen

burning of tires is more toxic; for instance, it causes a mutation (Transition in the cell DNA). It includes "Criteria" pollutants, for example, unpredictable natural mixes (VOCs), oxides of nitrogen (NOx), sulfur oxides (SO), carbon monoxide (CO), and particulate matter (GROUP™, 2020). It also contains ("non-criteria") Hazardous harmful chemical (HAP) contaminants such as Benzene (C_6H_6), dioxins and furans, hydrogen chloride, polychlorinated biphenyl's (PCBs), polynuclear aromatic hydrocarbons (PAHs) and metals like arsenic, copper, cadmium, chrome nickel, and vanadium. Release from both criteria and non-criteria (HAP) emissions may pose acute (short-term) and chronic (long-term) health hazards such as skin damage, irritation in the eye, mucous membranes, respiratory effects, central nervous system depression, and cancer ((science-memo), 2020).

STUDY AREA

Visakhapatnam is a seaside port city located at 17.43° N and 83.18° E and an altitude of 33 m above mean sea-level with an area of 11,161 km², commonly known as the East Coast Jewel, located in Andhra Pradesh. The Visakhapatnam district is bordered by Odisha in the north-west, Vizianagaram in the north-east, a Godavari district in the southwest,and east by the Bay of Bengal. The city is also recognized as the Andhra Pradesh's best tourist hotspot. Visakhapatnam has everything from the water bodies to the astounding beaches, from the majestic hills to the caves and the valleys. Visakhapatnam has several famous landmarks and tourist hot spots that reflect real India's cultural heritage (Government, 2020). Visakhapatnam does indeed have a humid subtropical climatic conditions with slight fluctuations in temperatures all year round. May is hottest, and January is coldest months in the year with an average temperature of 32 °C and 23 °C. The humidity stays high throughout the year since the city is situated on the Bay of Bengal. The area of the investigation site is situated in the center of the city near the Greater Visakhapatnam Municipal Corporation office, where several air pollutants are monitored continuously 24x7, and the land use is in the midst of a blended-use development with Commercial, Business and Residential property.

DATA COLLECTION AND METHODS

Data on the quality of air pollutants of the study area in Visakhapatnam was collected from Central Control Room for Air Quality Management – All India, Central Pollution Control Board for a period of 3 years from 2018 to 2020. Data available were analyzed for 24-hour average, and the hourly average of pollutants PM, PM., SO, and NO, and exceedance factor method was used to understand the condition of air quality on the following days of pre-Diwali, Bhogi, during Diwali and Bhogi and Post Diwali and Bhogi days.

As per the National ambient air quality status & trends in India-2010 report

The Exceedance Factor (EF) is calculated by using the following formula

$$\text{Exceedance factor} = \frac{\text{Observed 24 hour / Annual Average concentration of Criteria pollutant}}{\text{24 hour / Annual standard for the respective pollutant and area class}}$$

The four air quality categories are:

- Critical pollution (C): when EF is > 1.5;
- High pollution (H): when the EF is between 1.0 - <1.5;
- Moderate pollution (M): when the EF between 0.5 - <1.0; and
- Low pollution (L): when the EF is < 0.5.

RESULTS AND DISCUSSIONS

The data analyzed show the potentiality of air quality in the study area during Diwali and Bhogi days.

Trends of 24-hour average air pollution during Diwali

Pollutant - Particulate Matter (Size <2.5 μm)

The findings from the Fig. 1 show the concentration of pollutant PM.is within the permissible limits as per National Ambient Air Quality Standards on Pre-Diwali day in 2018 and 2019. However, on Diwali day, the air quality was in Critical pollution (C) with Exceedance factor 1.795 in 2018 and 2.096 in 2019. Moreover, Post Diwali day of the year 2018, the air quality was also in Critical pollution (C) with Exceedance factor 2.818 (Table 1), which is much higher than the Diwali day, and in the year 2019 post-Diwali is much cleaner than 2018.

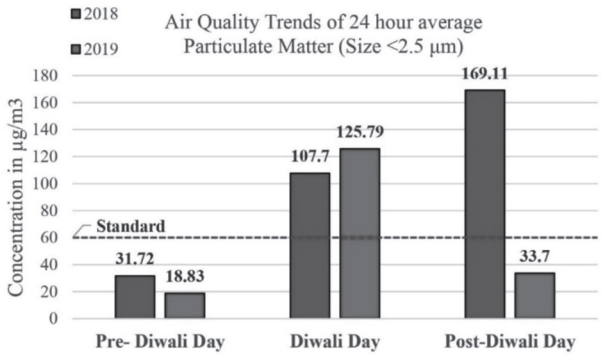

Fig. 1. Concentration of 24 Hour avg. Pollutant PM. during Pre-Diwali, Diwali and Post Diwali days

Pollutant - Particulate Matter (Size <10ìm)

The findings from the Fig. 2 show the concentration of pollutant PM10 is within the permissible limits on Pre-Diwali day for both the year. However, on Diwali day, the air quality was in Critical pollution (C) with Exceedance factor 1.703 (Table 2) in the year 2018 and 2.015 (Table 2) in the year 2019. And post-Diwali day of the year 2018, the air quality was also in Critical pollution (C) with Exceedance factor 1.683 (See Table II), and the year 2019 post-Diwali saw a decrease in pollutant than in the year 2018.

Pollutant - Sulphur Dioxide (SO) and Nitrogen Dioxide (NO)

The findings from the Fig. 3 and Fig. 4 show the concentration of pollutant SOand NOis within the permissible limits as per National Ambient Air Quality Standards on Pre-Diwali day, Diwali, and Post Diwali day in 2018 and 2019. However, in the year 2018, SO has been increased by 30% on Diwali

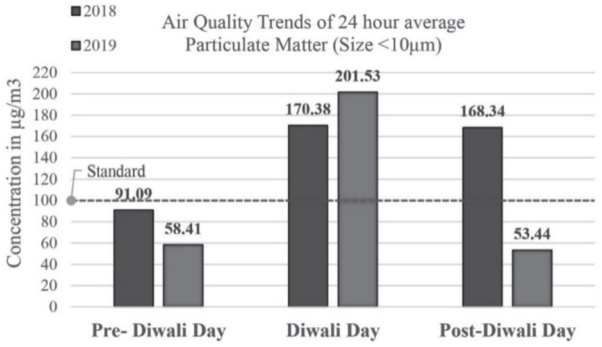

Fig. 2. Concentration of 24 Hour avg. Pollutant PM during Pre-Diwali, Diwali and Post Diwali days

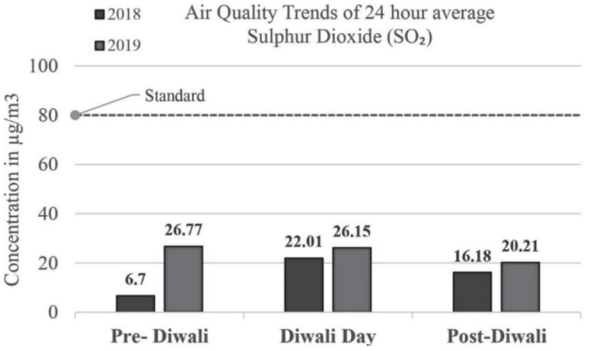

Fig. 3. Concentration of 24 Hour avg. Pollutant SO during Pre-Diwali, Diwali and Post Diwali days

Table 1. Calculated EF (Exceedance Factor) Air Quality Category - Particulate Matter (Size <2.5 µm)

Day	Year	Pollutant 24 Hr. Avg. (µg/m^3)	EF	Air Quality
Pre-Diwali Day	2018	31.72	0.528	Moderate
	2019	18.83	0.313	Low
Diwali Day	2018	107.7	1.795	Critical
	2019	125.79	2.096	Critical
Post-Diwali Day	2018	169.11	2.818	Critical
	2019	33.7	0.561	Moderate

Table 2. Calculated EF (Exceedance Factor) Air Quality Category - Particulate Matter (Size <10 µm)

Day	Year	Pollutant 24 Hr. Avg. (µg/m^3)	EF	Air Quality
Pre-Diwali Day	2018	91.09	0.910	Moderate
	2019	58.41	0.584	Moderate
Diwali Day	2018	170.38	1.703	Critical
	2019	201.53	2.015	Critical
Post-Diwali Day	2018	168.34	1.683	Critical
	2019	53.44	0.534	Moderate

day, and for the pollutant NO, there are no significant changes observed for the year 2018 and 2019. The Exceedance factor of the pollutant SO and NOis Low (Table 3 and 4).

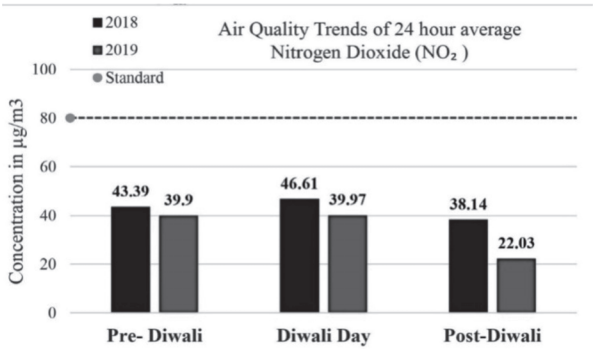

Fig. 4. Concentration of 24 Hour avg. Pollutant NO during Pre-Diwali, Diwali and Post Diwali days

Trends of One-hour average air pollution during Diwali

Pollutant - Particulate Matter (Size <2.5 µm and <10 µm)

The observations of one-hour average air pollutant PM. and PM on Diwali day demonstrated significant changes. One hour before firecrackers have burned the concentration of air pollutant PM. was as low as 31.5 µg/m^3 and 21 µg/m^3 and PM was 62.75 and 31.75 in the year 2018, and 2019 and the air pollution was instantaneously increased and reached a critical level when people started burning firecrackers, the highest concentration recorded PM.was 840 µg/m^3, 766 µg/m^3 and PM was 680 µg/m^3, 863 µg/m^3 in the year 2018 and 2019 (Fig. 5 and 6). And after completion of burning firecrackers, the air pollution slowly decreased and reached to normality at 10 AM on post-Diwali day.

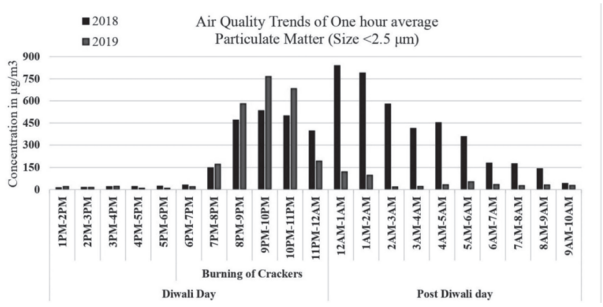

Fig. 5. Concentration of one-hour avg. Pollutant PM. during Diwali and Post Diwali day

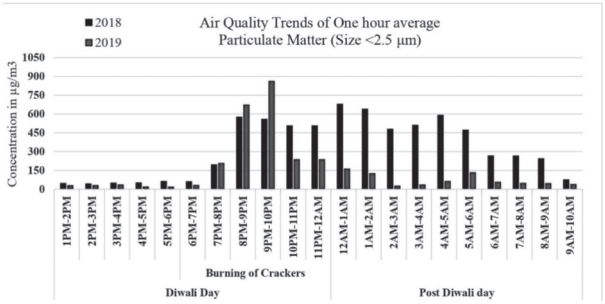

Fig. 6. Concentration of one-hour avg. Pollutant PM during Diwali and Post Diwali day

Table 3. Calculated EF (Exceedance Factor) Air Quality Category - Sulphur Dioxide (SO)

Day	Year	Pollutant 24 Hr. Avg. (µg/m^3)	EF	Air Quality
Pre-Diwali Day	2018	6.7	0.08	Low
	2019	26.77	0.334	Low
Diwali Day	2018	22.01	0.275	Low
	2019	26.15	0.326	Low
Post-Diwali Day	2018	16.18	0.202	Low
	2019	20.21	0.252	Low

Table 4. Calculated EF (Exceedance Factor) Air Quality Category - Nitrogen Dioxide (NO)

Day	Year	Pollutant 24 Hr. Avg. (µg/m^3)	EF	Air Quality
Pre-Diwali Day	2018	43.39	0.542	Moderate
	2019	39.9	0.498	Low
Diwali Day	2018	46.61	0.582	Moderate
	2019	39.97	0.499	Low
Post-Diwali Day	2018	38.14	0.476	Low
	2019	22.03	0.275	Low

Pollutant - Sulphur Dioxide (SO) and Nitrogen Dioxide (NO)

Diwali day's observations of average one-hour air pollutant SO and NO showed significant changes. One hour before firecrackers are burned the concentration of air pollutant SO was as low as 4.1 μg/m^3 and 21.95 μg/m^3 and NO was 12.52 and 21.6 in the year 2018 and 2019 and the air pollution was increased when burning firecrackers started, the highest concentration recorded SO was 122.75 μg/m^3, 40.52 μg/m^3 and NO was 100.78 μg/m^3, 56.15 μg/m^3 in the year 2018 and 2019 (Fig.7 and 8).

Trends of 24-hour average air pollution during Bhogi

Pollutant - Particulate Matter (Size <2.5 μm and Size <10)

The findings from the Fig. 9 and 10 shows the concentration of pollutant PM. and PM is above the permissible limits on Pre-Bhogi, Bhogi and Post-Bhogi days in 2018, 2019 and 2020. However, on Bhogi day the air quality showed a tremendous change in the pollution with an increase of 81.72% in 2018, 66.91% in 2019, and 72.09% in the year 2020

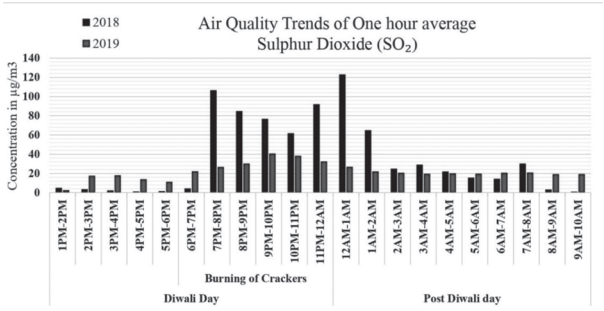

Fig. 7. Concentration of Pollutant SO during Diwali and Post Diwali day

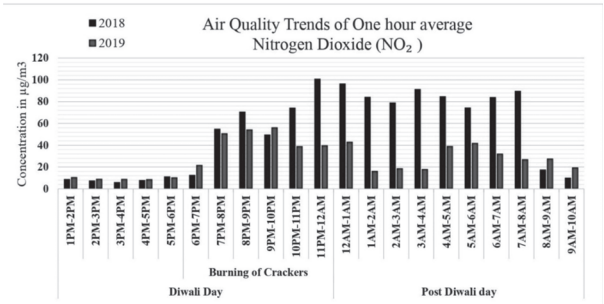

Fig. 8. Concentration of one-hour avg. Pollutant NO during Diwali and Post Diwali day

Table 4. Calculated EF (Exceedance Factor) Air Quality Category - Particulate Matter (Size <2.5 μm)

Day	Year	Pollutant 24 Hr. Avg. (μg/m^3)	EF	Air Quality
Pre-Bhogi Day	2018	111.45	1.857	Critical
	2019	120.94	2.015	Critical
	2020	102.65	1.710	Critical
Bhogi Day	2018	202.52	3.375	Critical
	2019	201.85	3.364	Critical
	2020	176.66	2.933	Critical
Post-Bhogi Day	2018	111.82	1.863	Critical
	2019	65	1.083	High
	2020	88.86	1.481	High

Table 5. Calculated EF (Exceedance Factor) Air Quality Category - Particulate Matter (Size <10 μm)

Day	Year	Pollutant 24 Hr. Avg. (μg/m^3)	EF	Air Quality
Pre-Bhogi Day	2018	207.84	2.078	Critical
	2019	207.36	2.073	Critical
	2020	237.97	2.379	Critical
Bhogi Day	2018	290.65	2.906	Critical
	2019	312.04	3.120	Critical
	2020	312.39	3.123	Critical
Post-Bhogi Day	2018	196.32	1.963	Critical
	2019	266.89	2.668	Critical
	2020	178.48	1.784	Critical

for PM. and PM an increase of 39.84% in 2018, 50.48% in 2019 and, 31.27% in the year 2020. Table 4 and Table 5 shows the air quality and its exceedance factor.

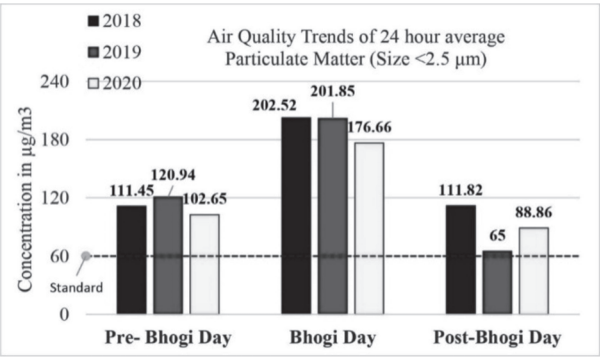

Fig. 9. Concentration of 24-hour avg. Pollutant PM.during Pre-Bhogi, Bhogi and Post-Bhogi day

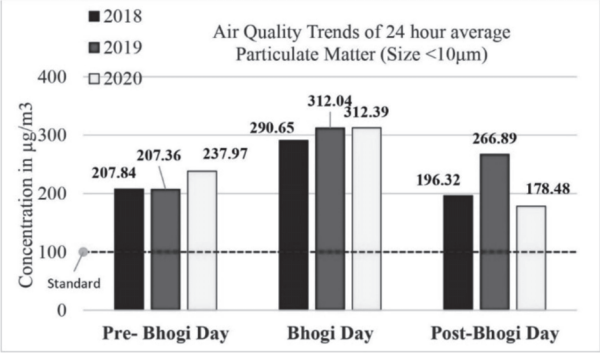

Fig. 10. Concentration of 24-hour avg. Pollutant PM during Pre-Bhogi, Bhogi and Post-Bhogi day

Pollutant - Sulphur Dioxide (SO) and Nitrogen Dioxide (NO)

The findings from the Fig. 11 and 12 show the concentration of pollutant SO and NO exceeded the permissible limits in the year 2019 during Bhogi day. The Air quality didn't show any significant changes in the level of pollution concerning SO.

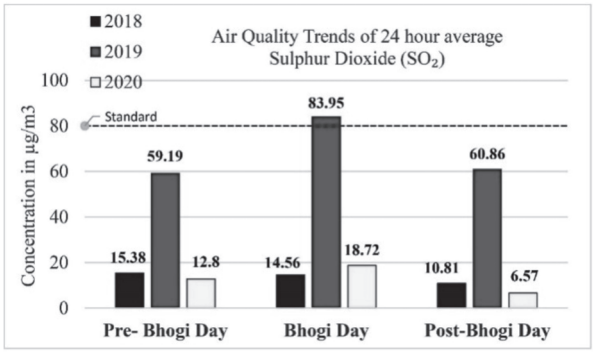

Fig. 11. Concentration of 24-hour avg. Pollutant SO during Pre-Bhogi, Bhogi and Post-Bhogi day

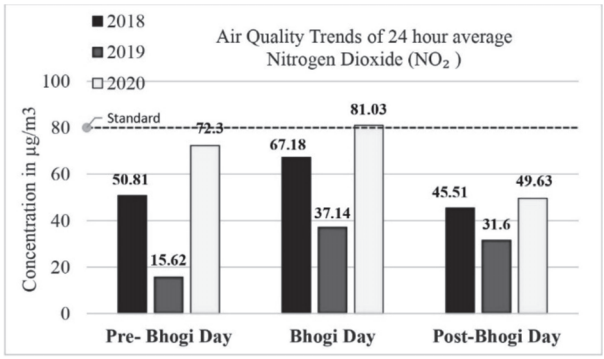

Fig. 12. Concentration of Pollutant NO during Pre-Bhogi, Bhogi and Post-Bhogi day

However, there is a slight increase in air pollution levels of NO on the day of Bhogi when compared to the air pollution level on Pre-Bhogi day. Table 6 for details of air quality and exceedance factor of SO and NO.

Trends of One-hour average air pollution during Diwali

Pollutant - Particulate Matter (Size <2.5 µm and <10 µm)

The one-hour average air pollution PM. and PM on Bhogi day exhibited significant changes. Early

Table 6. Calculated EF (Exceedance Factor) Air Quality Category - SO

Day	Year	Pollutant 24 Hr. Avg. (µg/m³)	EF	Air Quality
Pre-Bhogi Day	2018	15.38	0.192	Low
	2019	59.19	0.739	Moderate
	2020	12.8	0.16	Low
Bhogi Day	2018	14.56	0.182	Low
	2019	83.95	1.049	High
	2020	18.72	0.234	Low
Post-Bhogi Day	2018	10.81	0.135	Low
	2019	60.86	0.760	Moderate
	2020	6.57	0.082	Low

morning pollution increased substantially from 4:00 a.m onwards, as people wake up at dawn and begin the burning of wood, rubber tyres and other materials between 4 a.m. and 9 a.m. At 3 am, the PM. air pollution level was around 123 μg/m^3, 220.25 μg/m^3, and 199.75 μg/m^3 at 1am the PM was 152 μg/m^3, 351.75 μg/m^3 and 220.75 μg/m^3 for the years 2018, 2019 and 2020 and gradually the air pollution increased when people began burning, and the highest concentrations of PM. recorded were 667.45 μg/m^3, 526.75 μg/m^3 and 526.14 μg/m^3, and PM was 825 μg/m^3, 875 μg/m^3, 876 μg/m^3 in 2018, 2019 and 2020 (Fig 13 and 14). And after completion of burning firewood and other materials, the air pollution slowly decreased and reached to normality at 1PM on Bhogi day.

Pollutant - Sulphur Dioxide (SO) and Nitrogen Dioxide (NO)

The one-hour average air pollutant of SO and NO

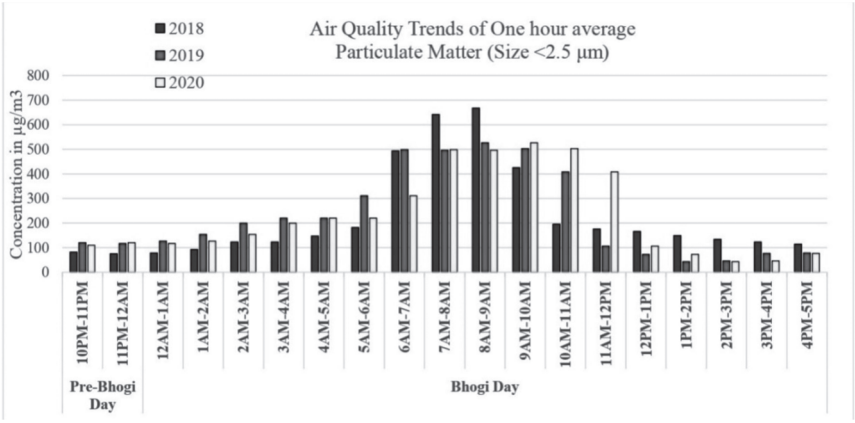

Fig. 13. Concentration one hour average of Pollutant PM.on Bhogi day

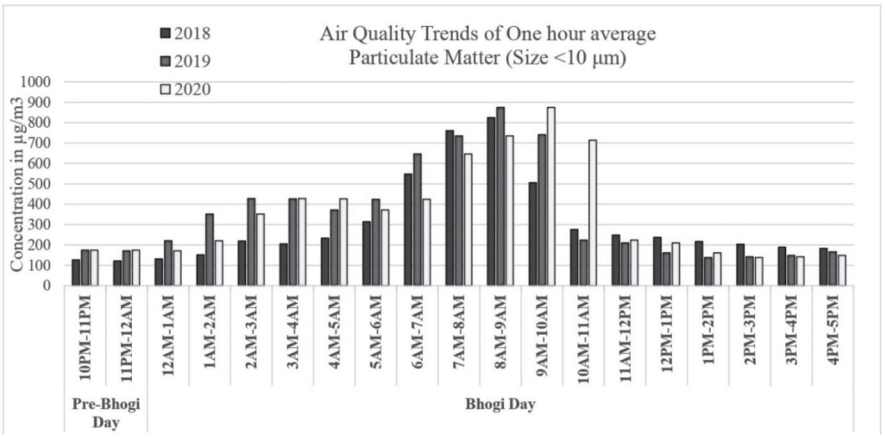

Fig. 14. Concentration of one hour average of Pollutant PMon Bhogi day

Table 7. Calculated EF (Exceedance Factor) Air Quality Category - NO

Day	Year	Pollutant 24 Hr. average (μg/m^3)	EF	Air Quality
Pre-Bhogi Day	2018	50.81	0.635	Moderate
	2019	15.62	0.195	Low
	2020	72.3	0.903	Moderate
Bhogi Day	2018	67.18	0.839	Moderate
	2019	37.14	0.464	Low
	2020	81.03	1.012	High
Post-Bhogi Day	2018	45.51	0.568	Moderate
	2019	31.6	0.395	Moderate
	2020	59.63	0.745	Moderate

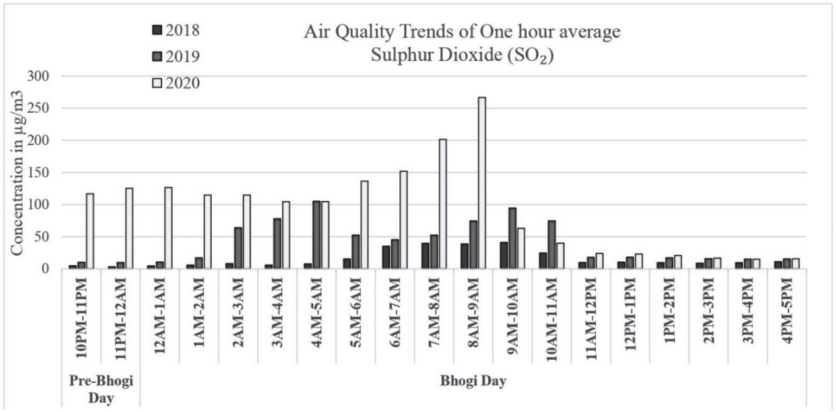

Fig. 15. Concentration of one hour average of Pollutant SO on Bhogi day

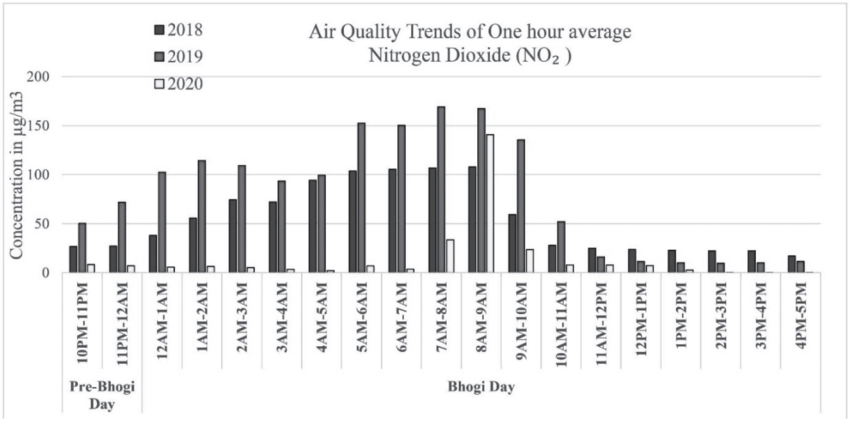

Fig. 16. Concentration of one hour average of Pollutant NO on Bhogi day

observations on Bhogi Day revealed substantial changes. At 1am the air pollution levels of SO was 5.72 µg/m^3, 17.15 µg/m^3, and 114.67 µg/m^3 and NO was 55.83 µg/m^3, 114.3 µg/m^3, and 6.45 µg/m^3 and the air pollution

Increased to critical level from 4am to 10 am, and the highest concentration recorded SO was 41.05 µg/m^3, 105.17 µg/m^3, and 266.73 µg/m^3 and NO was 108 µg/m^3, 169.22 µg/m^3, and 140.8 µg/m^3 in the year 2018, 2019, and 2020 (Fig. 15 and 16).

CONCLUSION

Air quality in the study area during Diwali and Bhogi Days revealed a significant increase in pollutants PM., PM, SO, and NO. The PM.and PM aerosols have shown a significant rise over SO, NO. During Diwali, the pollutant PM.risen by 239.10 percent in 2018, and 568.47 percent in 2019 and PM continued to increase by 87 percent in 2018 and 244 percent in 2019 and during Bhogi, PM. increased by 81.7 percent in 2018, 66.9 percent in 2019 and 72.09 percent in 2020 and PM by 39.84 percent, 50.04 percent and 31.27 percent in 2018, 2019 and 2020. Such short-term, high exposure to pollutant particulate matter would undoubtedly impact humans and the environment.

On humans, these pollutants can cause severe lung damage, worsening pre-existing heart disease, slow immune response, prone to viral function, damage to the growing fetus, premature mortality. These pollutants also have a significant impact on the environment and ecosystems. It is, therefore important to sensitize citizens on the potential risks of burning firecrackers during Diwali, and firewood, plastic, and rubber tyres during Bhogi and Government should gradually ban burning of these during festivals.

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