Sustainable Chemical Engineering
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Research Article

Environmental Assessment of Toxic Gases and Particulate Matter ($PM_{2.5}$) Monitoring During Fireworks Episodes (Diwali Festival) in Chennai Metropolitan, Southern India

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Received: 8 November 2023; **Revised:** 2 January 2024; **Accepted:** 4 January 2024

Abstract: The Indian celebration of lights, Diwali, is very important. This yearly event in October or November involves spectacular fireworks. Sparklers increase PM and harmful chemicals in the environment. It's no surprise that events affect air quality. This study measured Total Gaseous Mercury (TGM), Particulate Matter (such as $PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Nitric Oxide (NO), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x), and Ozone (O_3) in Chennai, a densely populated metropolitan area in Tamil Nadu, India, before, on, and after Diwali. It was to determine how firecrackers affect air quality. Southwest (SW) and south-southwest winds predominate before Diwali. During Diwali, west-northwest and south-southwest wind speeds were highest. The average wind speed is 0.2-2.0 m/s. The average gaseous component concentration decreased pre- and post-Diwali. Wind direction and gaseous component distribution show Diwali sparklers were the main source of toxicity. A novel method measures wind patterns and velocities before, during and after Diwali to determine air quality dynamics. Gaseous component levels dropped significantly after Diwali, exceeding expectations. Firework emissions, meteorology and pollution dispersion were assessed. Public awareness efforts are needed since sparklers with lighting characteristics are the main source of Diwali pollution, according to the report. This new idea encourages sustainable, health-focused cultural events and urban environmental protection through data-driven decision-making.

***Keywords*:** air quality, fireworks, Chennai metropolitan, pollution sources

1. Introduction

The Hindu community commemorates the festival of lights by lighting candles and divas, with the contemporary practice of fireworks being observed in recent times. There are factors that may lead to adverse effects on both individuals and the environment. Explosions are often seen as having a detrimental impact, since the combustion of large explosions during celebratory events releases a variety of gases, including carbon dioxide, sulphur dioxide, and nitrogen dioxide, into the surrounding environment. The emission of gases may lead to significant air pollution. The

DOI: https://doi.org/10.37256/sce.5120243888

composition of the crackers includes potassium nitrate (75%), charcoal (15%), and sulphur (10%) as indicated by Drewnick[1] and Barman.[2] The impact of the use of large-scale firecrackers during global New Year celebrations has also been documented by many researchers.[3-5] Chennai, formerly known as Madras, is a prominent metropolis in India located along the Coromandel coastline of the Bay of Bengal. The annual average precipitation is around 1,400 mm, mostly derived from the northeast monsoons. The average annual temperature ranges from 35 to 40 °C. In general, metropolitan areas are often exposed to significant levels of air pollution, which includes the presence of metals resulting from automobile emissions and the emissions from thermal power plants, such as those generated by gas and steam turbines. Fireworks are often used globally to commemorate significant events in many countries, emitting trace gases such as carbon dioxide, sulphur dioxide, and nitrogen dioxide, as well as particulate matter including metals, into the atmosphere. Firecracker displays on festive occasions, such as Diwali (festival of lights), have the potential to contribute significantly to air pollution due to the release of various gases, particulate matter, and hazardous substances. During this auspicious occasion, fireworks are detonated, resulting in the release of hazardous gases and toxic compounds into the environment.

In the country of India, the festival known as Diwali or Deepawali is observed throughout the months of October and November, coinciding with the winter season. The emission of smoke during the detonation of fireworks has adverse effects on human health, particularly on respiratory function, and has been linked to the development of conditions such as asthma and bronchitis.[6] The Tamil Nadu Pollution Control Board (TNPCB) initiated an early Diwali awareness campaign to inform the public about the negative consequences associated with fireworks. This campaign included conducting surveys on air quality and noise levels in Chennai city and 10 other major cities. In accordance with the directives issued by the Central Pollution Control Board (CPCB), it is mandatory for all State Pollution Control Boards (SPCBs) and Union Territories (UTs) to conduct pollution monitoring activities during the Diwali festival on an annual basis. Kulshrestha[7] reported the highest levels of different particulate matter in the ambient air during the Diwali festival. The impact of the inhalation of salty smoke on human health has been shown to result in adverse effects such as hacking, suffocation, and the rapid onset of severe Acute Eosinophilic Pneumonia (AEP).[8] Several researchers in India and other locations conducted studies on the impact of particulate matter and harmful gases released during festivals such as Diwali. These studies focused on the short-term degradation of air quality, adverse effects on human health, and long-term implications for climate change. Notable contributions in this area include the works of Onyancha et al., Suresh et al., Hussain et al., Devara et al., Betha et al., Chatterjee et al., Thakur et al., and Bach et al.[9-16] Several researchers in India, including Rao et al.,[17] Papiya Mandal,[18] Cinzia Perrino,[19] Barman[2] and Singh[20] conducted studies on the air quality standards during the Diwali season and noise-induced pollution in Delhi and Lucknow.

In the present environment, comprehensive dispersed assessments are currently being conducted in the Chennai Metropolitan area of Tamil Nadu, India. Considering the material. We have examined, and analyzed the ambient air quality of Chennai localities. One may experience asphyxiation due to the excessive release of hazardous gases, as well as the consumption of poisonous confectioneries in excessive quantities. This paper primarily focuses on studying the pollution scenario during the Diwali festival in the Chennai area. It examines the approaches taken to measure and understand the levels of particulate matter ($PM_{2.5}$), Total Gaseous Mercury (TGM), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Nitric Oxide (NO), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x), and Ozone (O_3) before Diwali, during Diwali, and after Diwali. These periods are considered to be the most sensitive and illustrative of the impact of firecrackers on air quality, scattering and transport phenomena, and potential health effects in the urban environment of the Chennai region. To assess the environmental impact of firecracker emissions during Diwali festivities, this study aims to measure the variability in air particulate matter and harmful gaseous components. Analysis of wind patterns and speeds shows how pollutants migrate, emphasizing the significance of particular remedies. Unexpectedly, a drop in petrol levels challenges conventional assumptions, requiring a more exact technique for analysing festival air pollution. The identification of sparklers with lights as a major source of toxins affects regulation and awareness. For sustained cultural celebrations, evidence-based decision-making is essential. This study introduces a new approach to cultural traditions and environmental responsibility in densely populated cities.

2. Materials and methods

Chennai, the capital city of Tamil Nadu, has the distinction of being the fourth biggest urban centre in India. Geographically, Tamil Nadu is located on the southeastern coast of the Bay of Bengal. Chennai, located in close proximity to the Bay of Bengal, serves as a prominent centre for commercial activities in the metropolitan landscape of India. Its strategic geographical position gives it convenient access to the business sectors in East Asia, therefore establishing itself as a crucial hub for entrepreneurs and business professionals. In addition to logistics, the automotive industry, software services, healthcare, and industrial sectors contribute significantly to the economic foundation of Chennai city. The research site is located within the Anna University Campus in Chennai, Tamil Nadu State, India. The coordinates of the site are 13° 0' 45.05" N and 80° 14' 2.66" E, with an average elevation of 49 feet above sea level. The location under consideration is located in the northeastern direction and is surrounded by a combination of small and large-scale companies as well as power plants. It has been observed that whenever the wind blows from the northeast sector, the investigation site becomes contaminated. The meteorological data, such as wind speed, wind direction, and the composition of gases in the atmosphere, including Particulate Matter ($PM_{2.5}$), Total Gaseous Mercury (TGM), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Nitric Oxide (NO), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x), and Ozone (O_3), was examined during the periods preceding Diwali (one day prior), Diwali itself, and the day following Diwali. The Institute for Ocean Management at Anna University in Chennai continuously noted an emphasis on measuring the Total Gaseous Mercury (TGM) concentration. Various gaseous data were collected from the web-based monitoring station of the Central Pollution Control Board located at the Indian Institute of Technology, Madras in Chennai.

The gaseous contaminant was examined using computerized electronic vapour monitoring equipment. In this study, the analysis of SO_2 and NO_2 was conducted utilizing the techniques of UV fluorescence and chemiluminescence, with a focus on providing a comprehensive examination of these substances.[21] The UV photometric approach was used to analyse O_3, while non-dispersive infrared spectroscopy was utilized to assess CO. The meteorological data was gathered from automated weather stations. At each 15-minute period, systematic data sets, including parameters, were gathered. The Tekran 2537B automated mercury vapour analyzer analysed Total Gaseous Mercury (TGM). Two implicit gold cartridges capture and thermally desorb mercury. Karthik[22] presented daily automatic calibrations utilising the instrument's internal alignment source at 3.10 and 3.40 PM. Periodic internal calibration reduces span and zero value irregularities caused by temperature and fluorimeter lamp aging. The air flow rate of 5 L min^{-1} was monitored at specified intervals for analysis. Mao[22] explains air testing and device precision. Lower detection limits for Total Gaseous Mercury (TGM) are less than 0.1 ng m^{-3}. The estimation and activity have a precision of ± 5%. The instrument was airless-cleaned for clarity. The Airstream was collected using a PFA Teflon tube, which transferred RGM around 100% efficiently. RGM seldom changed less than 2%.

3. Results and discussion

3.1 *Diurnal variation of particulate and poisonous gaseous segments*

Table 1 presents the categorization of various gaseous components, including Total Gaseous Mercury (TGM), Particulate Matter ($PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Nitric Oxide (NO), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x), and Ozone. These components were analyzed during the periods preceding Diwali, Diwali, and the aftermath of Diwali. The primary potential source of sulphur dioxide (SO_2) and carbon monoxide (CO) emissions may be attributed to urban infrastructure and exhaust emissions from cars powered by the combustion of fossil fuels. The wind direction observed on the day before Diwali had a Southwesterly (SW) and South-Southwesterly (SSW) bearing. Additionally, the highest wind speeds were seen in the west-northwest and south-southwest directions throughout the Diwali time. The observed wind speed typically falls between the range of 0.2 to 2.0 m/s. A decrease in the average rate of convergence was seen for SO_2, Particulate Matter, and Total Gaseous Mercury (TGM) prior to the Diwali festival. The concentration levels of SO_2 vary from 4.37 to 22.2 μg/m^3, $PM_{2.5}$ varies from 11.47 to 446.3 μg/m^3, and TGM ranges from 8.03 to 685.89 ng/m^3 throughout the period leading up to Diwali (see Figure 1). During the Diwali period, the concentration of SO_2 ranged from 7.64 to 53.47 μg/m^3, $PM_{2.5}$ ranged from 38.34 to 947.31 μg/m^3, and

TGM ranged from 93.81 to 1,575.47 ng/m^3 (Figure 2). The average concentration of sulphur dioxide (SO_2) was found to be 15.33 µg/m^3, particulate matter with a diameter of 2.5 micrometers ($PM_{2.5}$) was measured at 160.59 µg/m^3, and Total Gaseous Mercury (TGM) was recorded at 124.93 ng/m^3. These concentrations exhibited variations over the post-Diwali period, as seen in Figure 3. The average aggregation of the analyzed gas data does not exhibit any significant variation during the research period. According to previous experts, the distribution of TGM is most influenced by solar radiation, followed by wind direction.

Table 1. Minimum, maximum and mean concentration of different gaseous components during pre-Diwali, Diwali and post Diwali periods

Parameters	Pre-Diwali 17th October 2017			Diwali 18th October 2017			Post Diwali 19th October 2017		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Sulfur Dioxide (SO_2) - (µg/m^3)	4.37	22.20	8.38	7.64	53.47	16.46	2.74	44.64	15.33
Nitric Oxide (NO) - (µg/m^3)	3.62	115.00	33.72	4.3	124.65	30.13	3.21	43.03	9.15
Carbon Monoxide (CO) - (mg/m^3)	0.33	2.03	1.338	0.72	2.28	1.37	0.31	2.33	1.18
Nitrogen Dioxide (NO_2) - (µg/m^3)	0.02	40.32	13.14	0.42	64.83	31.25	13.82	66.15	38.91
Oxides of Nitrogen (NOx) - (ppb)	10.65	48.45	24.21	12.68	67.08	30.55	15.1	35.65	24.26
Ozone (O_3) - (µg/m^3)	0.16	7.36	3.86	1.91	66.69	16.97	2.38	172.15	45.42
Particulate Matter 2.5 - (µg/m^3)	11.47	446.30	90.16	38.34	947.31	202.92	31.88	917.45	160.59
Total Gaseous Mercury - (ng/m^3)	8.03	685.89	94.23	93.81	1,575.47	369.71	40.29	624.79	124.93

Min- Minimum; Max- Maximum; Avg- Average

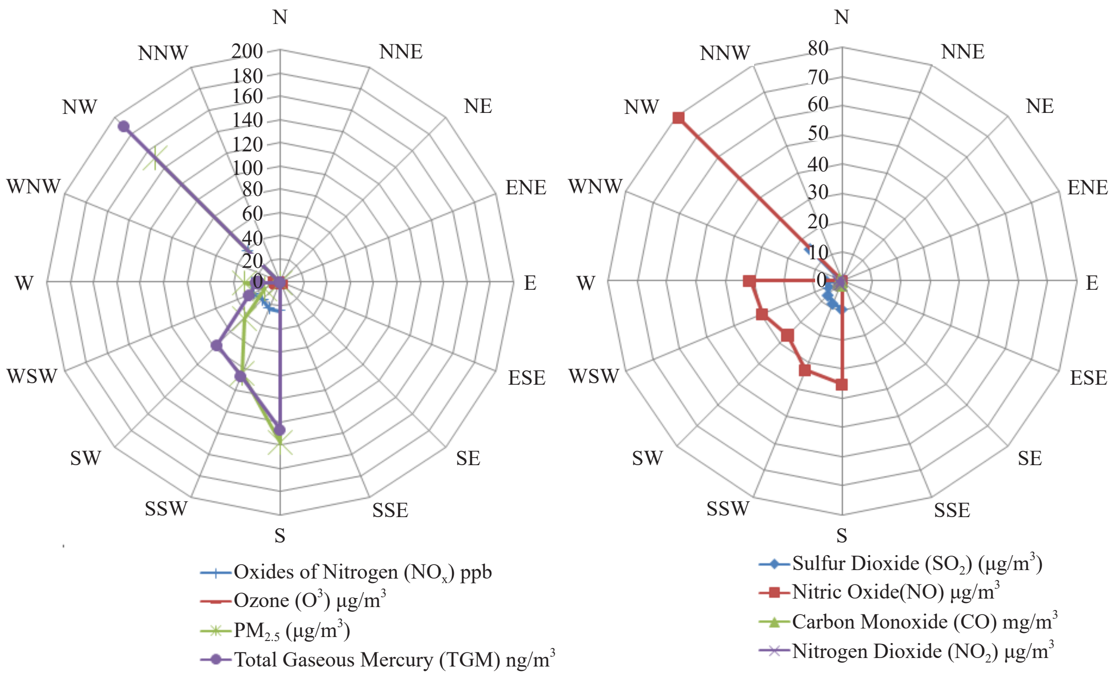

Figure 1. Ambient air quality vs wind direction of different gaseous components (TGM, $PM_{2.5}$, SO_2, NO_2, NO, CO, NO_x, Ozone) during pre-Diwali period

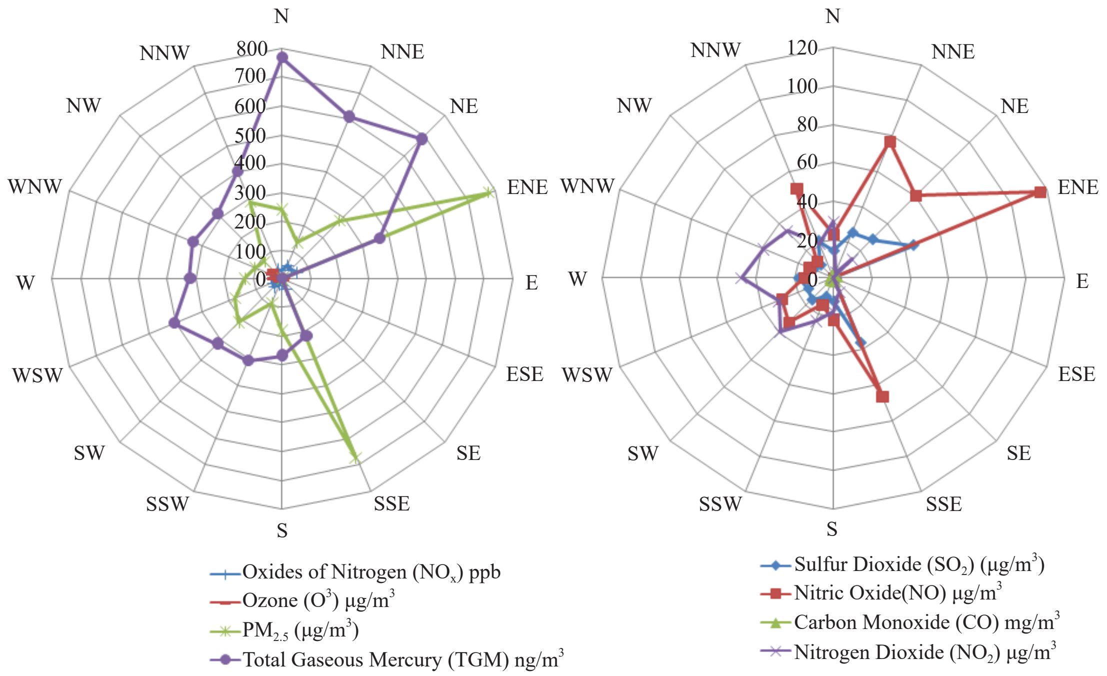

Figure 2. Ambient air quality vs wind direction of different gaseous components (TGM, $PM_{2.5}$, SO_2, NO_2, NO, CO, NO_x, Ozone) during Diwali period

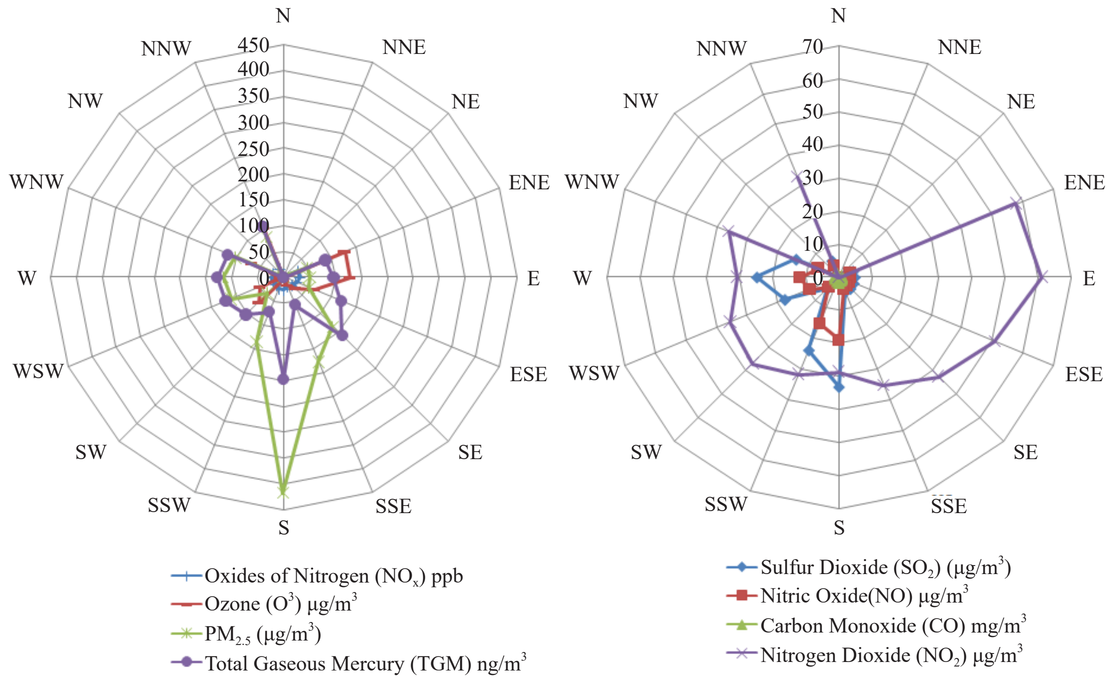

Figure 3. Ambient air quality vs wind direction of different gaseous components (TGM, $PM_{2.5}$, SO_2, NO_2, NO, CO, NO_x, Ozone) during post Diwali period

The primary sources of TGM in the atmosphere are derived from marine sources, as well as coal and waste incineration facilities.[23,24] During Diwali time, there were observed abrupt changes in the direction of wind gusts. The aforementioned result demonstrates that the Total Gaseous Mercury (TGM) is influenced and regulated by oceanic sources followed by wind direction. The most significant aggregation of gaseous components was seen during the Diwali festival and the subsequent time. The alignment of gaseous variables that are not significantly associated with a wind direction throughout the Diwali and post-Diwali period (Figure 4). The transportation of gaseous parameters is closely associated with pre-Diwali events. The aforementioned observation clearly indicates that the gaseous components are derived from local sources such as Diwali firecracker activities.[4,25] The apportionment of particulate matter ($PM_{2.5}$) also provides evidence for the aforementioned conclusion. The occurrence of gaseous components and Total Gaseous Mercury (TGM) fixation at regular intervals throughout the pre-Diwali, mid-Diwali, and post-Diwali periods is shown in Figure 5, 6, and 7, respectively. The aggregation of gaseous constituents, as shown by the TGM concentration, was found to be much higher during the evening hours of Diwali compared to daylight. This phenomenon may be attributed to the increased use of fireworks and crackers during the nighttime festivities. During the Diwali festival, the levels of gaseous components and Total Gaseous Mercury (TGM) concentrations increased throughout the day, as reported by Curtis.[26]

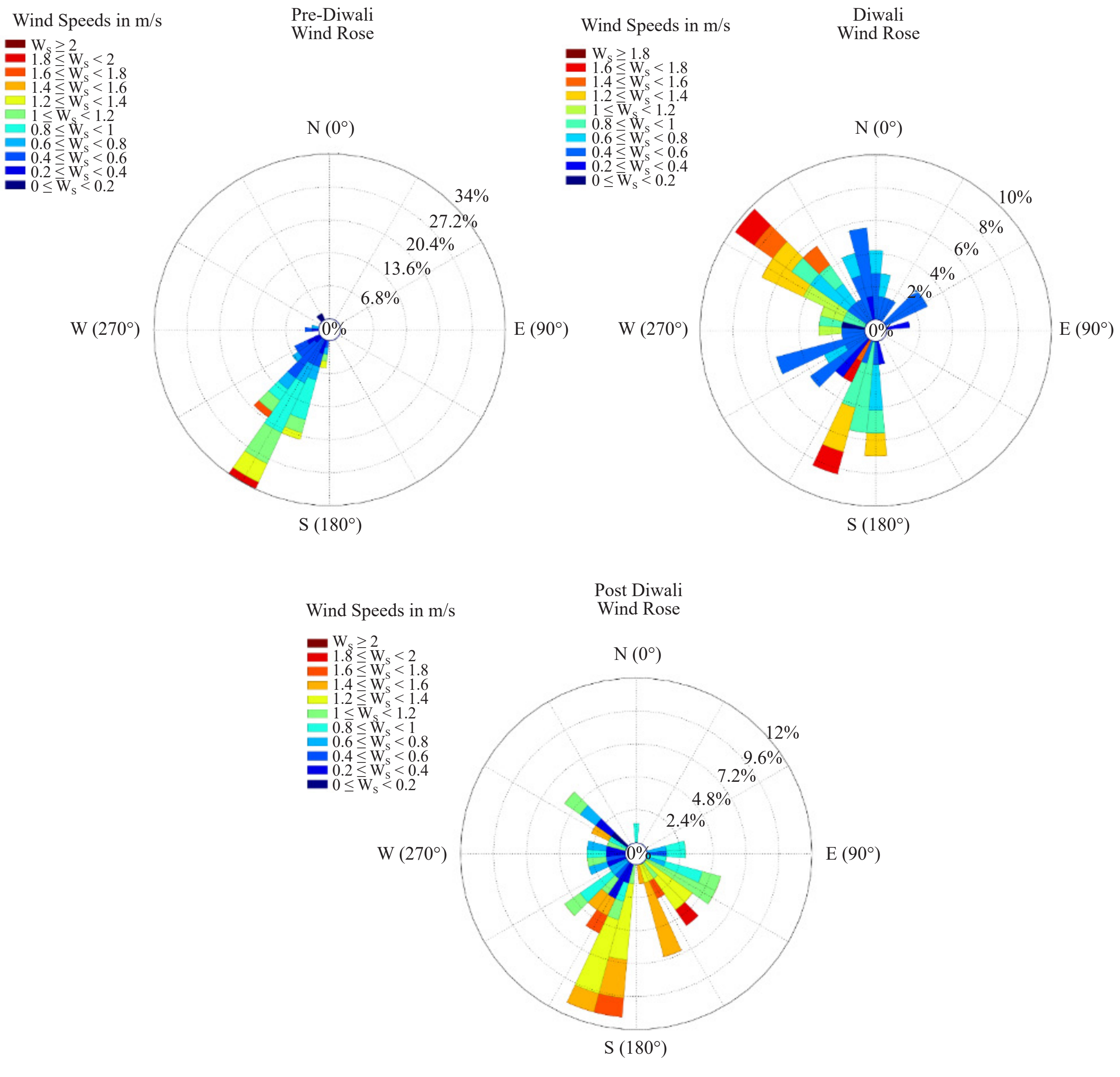

Figure 4. Rose diagram of wind direction vs wind speed of pre-Diwali, Diwali and post Diwali days, Chennai Metropolitan, India

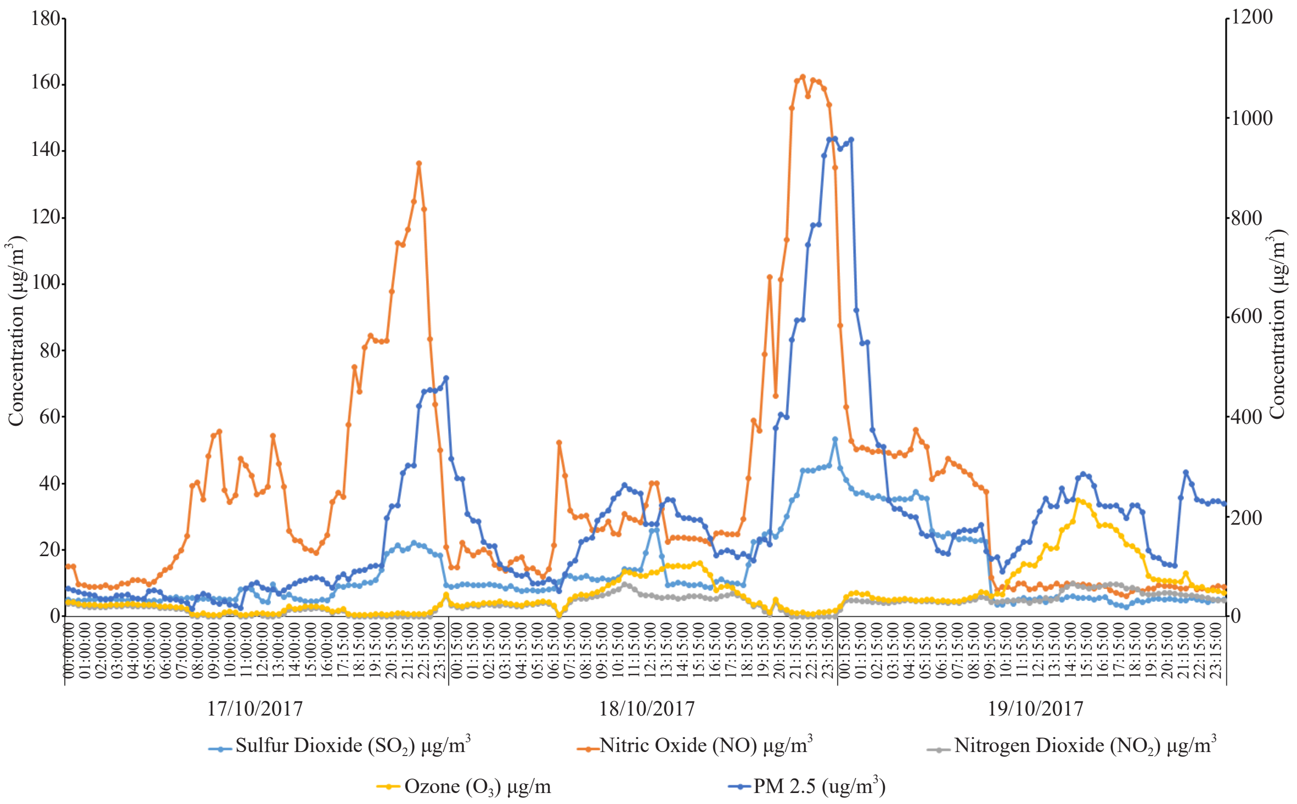

Figure 5. Variation of regular intervals of SO_2, NO, NO_2, O_3, $PM_{2.5}$ ratios during the entire monitoring period of Diwali campaign

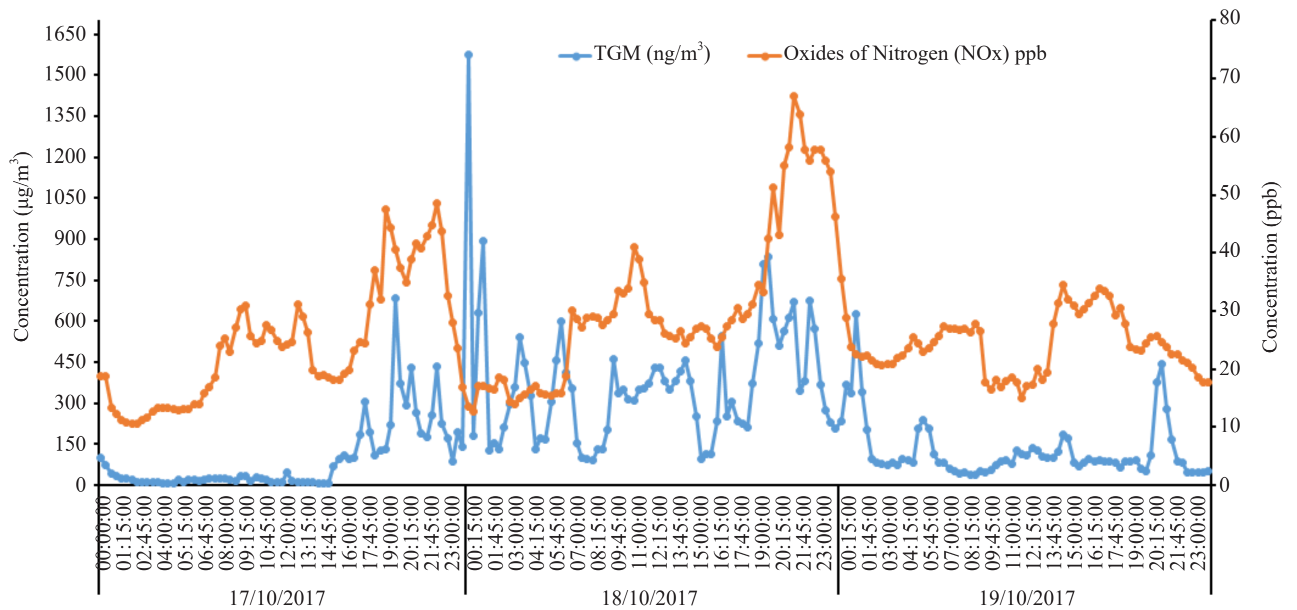

Figure 6. Variation of regular intervals of TGM, NO_x ratio during the entire monitoring period of Diwali campaign

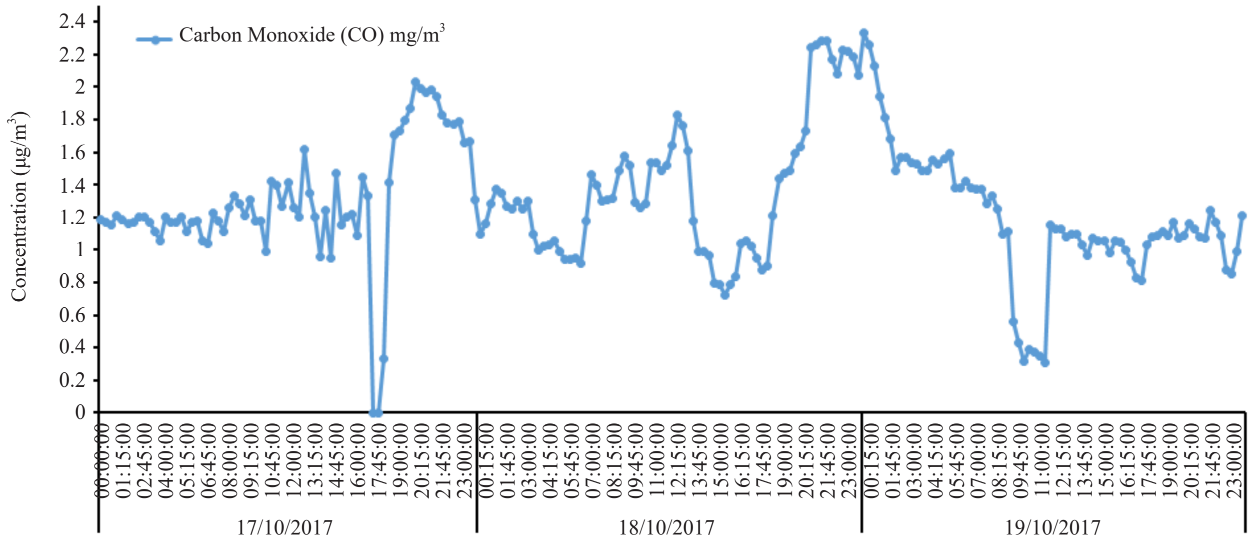

Figure 7. Variation of regular interval of CO ratio during the entire monitoring period of Diwali campaign

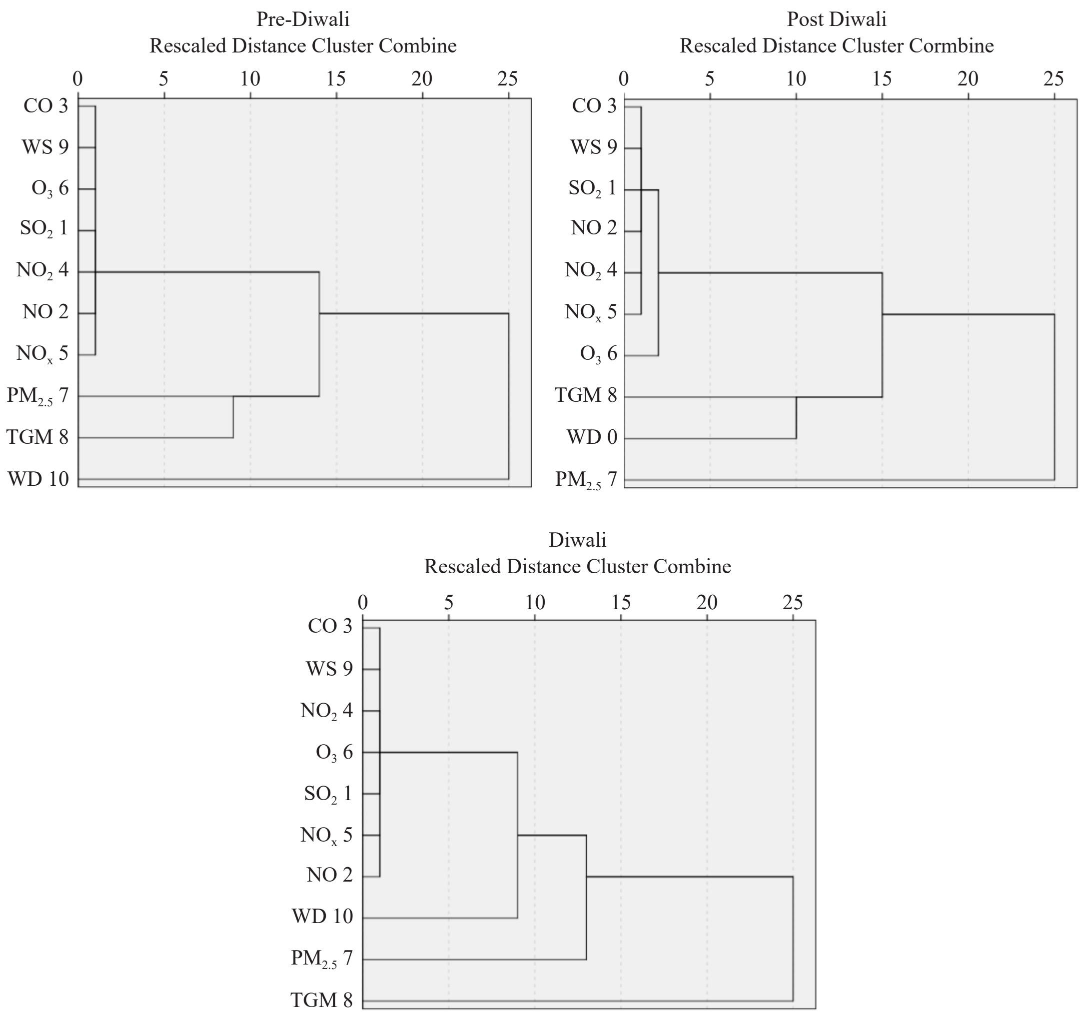

Figure 8. Dendrogram of the ambient air quality parameters during pre-Diwali and Diwali and post Diwali periods

Table 2. correlation matrix (R2) of the ambient air quality during pre-Diwali, Diwali and post Diwali period

	Parameters	SO_2	NO	CO	NO_2	NO_x	O_3	$PM_{2.5}$	TGM	WS	WD
Correlation matrix - pre-Diwali period	SO_2	1									
	NO	0.719	1								
	CO	0.608	0.587	1							
	NO_2	-0.393	-0.781	-0.345	1						
	NO_x	0.694	0.975	0.55	-0.799	1					
	O_3	0.671	0.431	0.374	-0.254	0.389	1				
	$PM_{2.5}$	0.922	0.601	0.55	-0.198	0.571	0.624	1			
	TGM	0.561	0.685	0.428	-0.357	0.674	0.235	0.476	1		
	WS	-0.094	-0.266	0.002	0.216	-0.215	0.054	-0.071	-0.237	1	
	WD	-0.086	0.145	-0.141	-0.227	0.132	-0.124	-0.155	0.009	-0.496	1
Correlation matrix - Diwali period	SO_2	1									
	NO	0.92	1								
	CO	0.885	0.829	1							
	NO_2	-0.614	-0.713	-0.517	1						
	NO_x	0.851	0.915	0.805	-0.411	1					
	O_3	-0.135	-0.22	-0.237	0.485	-0.069	1				
	$PM_{2.5}$	0.905	0.871	0.796	-0.616	0.75	-0.18	1			
	TGM	0.182	0.185	0.194	-0.248	0.143	-0.149	0.156	1		
	WS	-0.167	-0.228	-0.184	0.207	-0.181	0.514	-0.177	-0.202	1	
	WD	-0.199	-0.179	-0.166	0.321	-0.119	0.414	-0.175	-0.294	0.159	1
Correlation matrix - post Diwali period	SO_2	1									
	NO	0.842	1								
	CO	0.813	0.697	1							
	NO_2	-0.578	-0.599	-0.33	1						
	NO_x	0.042	0.212	0.225	0.652	1					
	O_3	-0.599	-0.579	-0.393	0.762	0.403	1				
	$PM_{2.5}$	0.665	0.579	0.76	-0.407	0.046	-0.38	1			
	TGM	0.3	0.144	0.462	-0.043	0.07	-0.107	0.516	1		
	WS	-0.189	0.027	0.063	-0.034	0.012	-0.12	0.245	0.072	1	
	WD	0.294	0.225	0.056	-0.582	-0.506	-0.254	0.034	-0.021	-0.281	1

3.2 *Correlation matric analysis*

Table 2 shows the correlation matrix (R2) of the ambient air quality parameters ($PM_{2.5}$, TGM, SO_2, NO_2, NO, CO, NO_x, O_3) during the pre-Diwali, Diwali, and post-Diwali periods. Zanobetti and Schwartz[3] conducted an assessment of the interrelationships among air quality metrics using a correlation matrix. This approach was used to investigate the sources of various components present in the environment. During the month before Diwali, there is a notable positive correlation seen between factor 1 and the pollutants SO_2, CO, and TGM. Additionally, factor 2 shows positive loadings for the pollutants SO_2, CO, O_3, and $PM_{2.5}$. During the Diwali season, it has been shown that SO_2, NO, CO, and $PM_{2.5}$ demonstrate positive loadings in factor 1, whereas O_3, Wind Speed (WS), and Wind Direction (WD) indicate positive loadings in factor 2. The link between induced air quality and drift was maintained over a post-Diwali period in factor 1. The slope that was seen before may have been altered due to the process of stacking factors. The compounds NO_2 and NO_x have a positive correlation in factor stacking, namely in factor 2. The comprehensive air quality data of the study area shows a consistent trend for both the Diwali and post-Diwali periods (see Table 3). The Dendrogram plot for air quality parameters suggests that $PM_{2.5}$, TGM, and NO_2 are mainly controlled by wind direction in a pre-Diwali period. Wind direction, O_3, $PM_{2.5}$ have a common relationship with different parameters. The above observation may be because the wind direction and O_3 are controlling the transport of particulate issue ($PM_{2.5}$) and Total Gaseous Mercury (TGM) content in the Diwali period. In any case, TGM isn't showing any enormity with various parameters. This relationship shows that the other incorporating air quality parameters and TGM are acquired from two unique sources.[27,28] Dendrogram plot for post-Diwali information recommend that the $PM_{2.5}$, TGM are acquired from comparable sources and the appropriation of this parameter is controlled by Wind Direction (WD) (Figure 8). Decrease the usage of crackers in the festivals or utilizations of hazardous parts like mercury, arsenic while assembling may control the encompassing level of air quality.

Table 3. Extracted factor loadings of ambient air quality during pre-Diwali, Diwali and post Diwali period

Parameters	Pre-Diwali - Component			Diwali - Component			Post Diwali - Component		
	1	2	3	1	2	3	1	2	3
SO_2	0.41	**0.87**	-0.008	**0.944**	0.229	0.03	**0.914**	0.126	0.294
NO	**0.868**	0.428	-0.157	**0.963**	0.162	-0.04	**0.849**	0.168	0.182
CO	**0.502**	**0.516**	0.198	**0.892**	0.17	-0.02	**0.805**	0.451	0.085
NO_2	-0.897	0	0.138	-0.739	0.267	-0.018	-0.773	**0.573**	0.145
NO_x	**0.894**	0.374	-0.117	**0.86**	0.303	-0.024	-0.163	**0.854**	0.319
O_3	0.122	**0.779**	0.079	-0.356	**0.769**	0.321	-0.747	0.322	0.232
$PM_{2.5}$	0.231	**0.919**	0.014	**0.903**	0.187	-0.017	**0.771**	0.373	-0.22
TGM	**0.593**	0.402	-0.123	0.286	-0.397	**0.664**	0.386	0.408	-0.155
WS	-0.111	-0.086	**0.873**	-0.315	**0.58**	0.484	0.038	0.223	-0.888
WD	0.121	-0.189	-0.825	-0.312	**0.594**	-0.413	0.377	-0.667	0.29

3.3 *Estimation of gaseous pollution and $PM_{2.5}$ depositions in health impacts*

Exposure to excessive quantities of noise has been shown to adversely affect the physical and physiological functioning of human organs, leading to symptoms such as nausea, vomiting, and exhaustion. The environmental inversion occurring during chilly Diwali nights adds to the accumulation of contaminants, while the trapping of pollutants under comparable circumstances leads to the creation of haze. Firecrackers emit pollutants and generate noise in the surrounding atmosphere, so posing a threat to the overall well-being of the inhabitants in the vicinity. During Diwali festivities, the potential health hazards associated with the combustion of firecrackers are significantly elevated due to the presence of chemicals such as sulphur oxides and particulate matter. These firecrackers often include a variety of substances including arsenic, sulphur, magnesium, sodium, iron, potassium chlorate, copper, manganese, cadmium, lead, zinc, and nitrates, which contribute to the increased health risks. Tiwari[29] has documented a deposition rate of 37% of fine particles inside the respiratory tract of individuals during the Diwali event in New Delhi, as indicated by a prior investigation. The significant increase in the concentration of Particulate Matter ($PM_{2.5}$) during Diwali poses a potential high risk to vulnerable populations such as the elderly and children, among others. The poor air quality conditions during Diwali and the period after Diwali may have a detrimental effect on a significant portion of the vulnerable population in terms of their health.

4. Conclusions

The study demonstrates that air pollution from Diwali firecrackers is caused by high concentrations of respirable particulates like $PM_{2.5}$, Total Gaseous Mercury (TGM), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Nitric Oxide (NO), Carbon Monoxide (CO), NO_x, and Ozone. From pre-Diwali to post-Diwali in Chennai's urban area, neighbouring meteorological and wind directions are used to study airborn characteristics. Diwali has less effect compared to 'terrain India' events. On Diwali, many crackers and sparklers are burned, causing increased toxicity and a drop in temperature. Without value control, crackers in India contain more poisons. There is little administrative structure to screen cracker quality. The sparklers' toxic materials release harmful gases that harm all living things. These contaminations were high during Diwali, which may have health effects.

From Pre-Diwali to Diwali days, essential alterations in the peak estimate of 20% to 50% in a few and particulate matter $PM_{2.5}$, vaporous sections metrics like TGM, SO_2, NO_2, NO, CO, NO_x, and Ozone focus were noticed, depending on site variety. The climate parameter estimate tends to decrease after Diwali. This research supports and confirms previous findings that air segment transportation wonders like Chennai location may have increased the centralization of every atmospheric parameter before Diwali. Similar effects were seen with ozone and NO_x. Its variations also showed alterations in TGM, SO_2, NO, CO, and NO_2. To compress all the most likely sources of evidence of the general lessening or improvement of the above parameters, the development and upgrade of the high convergence of airborne build-up properties of pressurized canned products in the environment, unfavorable meteorological conditions, and shifts in transport mist concentrate of harvest deposit consuming and firecrackers. On the whole, Diwali contributes to Chennai's pollution problem, albeit only temporarily. People usually think of Diwali pollution as particles, SO_2, NO_x, etc. Describe specific tracers sent during firework situations to demonstrate an improved understanding of the real event. Pollution scenarios are similar and impacted by similar causes of relationship and change, such as firework pollution, and sustained by similar weather circumstances at multiple sites. Low to extremely poor vision owing to intense fog. The paper presents pieces of evidence and offers ways to reduce Diwali fireworks pollution. Extreme firework use turns the clean, bright surroundings into murky, toxic air filled with explosive smoke, $PM_{2.5}$, and noise. Air contamination caused by elevated particulate matter, especially during a limited timeframe (event), significantly affects neighborhood atmospheric chemistry and eventually, human health, which isn't desirable and must be transported to an allowable level to maintain air quality a strategic distance from the dangerous impacts of air contamination on nearby residents. The investigation recommends quick legislation and quality control for Indian firecrackers during Diwali from environmental authorities, legislators, and the fireworks business. It raises the global issue of festival airborne pollution and the need to recognize regional variances for targeted interventions. The research implies eco-friendly fireworks alternatives might reduce hazardous emissions. It proposes legislative changes, industry collaboration, and ecologically friendly firework choices for sustainable celebrations without sacrificing air quality or public health.

Acknowledgments

The authors express their heartfelt gratitude to their respective institutions and the authors whose papers were utilized in this study.

Conflict of interest

The authors declare there is no competing financial interest.

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