Assessment of Extreme Firework Episode in a Coastal City of Southern India: Kannur as a Case Study

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Abstract

Bursting of firecrackers turns out to be a vital part of festivals and celebrations. The amount of air and noise pollutions caused by such celebrations has been increasing significantly for the past few years till the COVID episode. Particulate matter and toxic gases emitted as part of fire bursting pose a serious threat to human health. A variety of festivals and celebrations taking place in different parts of India pollute the rural and urban areas. Vishu is a regional New Year festival being celebrated with coordinated fireworks all over the south Indian state of Kerala. Intense fireworks usually start on the eve of Vishu from 18:00 to 22:00 h (IST) and on the day of Vishu from 04:00 to 07:00 h in two spells, which create smoke and dust in the atmosphere that leads to deterioration of air quality. Here, we describe the variations of surface ozone (O_3) and other trace pollutants for pre-, post- and Vishu days for two successive years (2020 and 2021) at Kannur town. No significant variations in air pollutants were observed on the Vishu days in 2020 due to countrywide lockdown to curb the transmission of COVID in India. But higher levels of trace pollutants were found during the intense fireworks during the two spells in the night of Vishu eve and early morning of Vishu day in 2021. Surface O_3 was found to be increased by 51%

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during the evening spell of fireworks on the eve of Vishu day and 61% on early morning spell on the Vishu day. A sharp increase in NO, NO_2, CO, SO_2, BTEX and NH_3, PM_{10} and $PM_{2.5}$ concentration was observed during the evening spell of fireworks on the eve of Vishu day and early morning spell on the Vishu day when compared to the respective time in the pre-Vishu days. Metal concentrations associated with particulate matter were found to be higher during Vishu days than pre- and post-Vishu days. The average concentrations of metals are shown in the order S > Al > Cl > Ca > K > Zn > Na > Mg > Pb > Cu > Ba > Cr > Fe > Ni > Sr > Mn. This shows that air pollution due to trace gases and particulate matter increases exponentially on fireworks days, unlike normal days. Such short duration activities carried out for visual and auditory pleasure have far-reaching effects. Therefore, it is evident that fireworks associated with celebrations and festivals are an event that can influence air quality to a large extent. In a densely populated area like Kerala, it is necessary to assess the consequences of such celebrations using fireworks and come up with a protocol for its use. Further, this work throws light on the absence of air pollution during the festival ban in 2020 in connection with a severe lockdown to curb COVID-19 transmission.

Keywords

Fireworks · COVID-19 · Air pollution · Air quality · Southern India

11.1 Introduction

Celebrations associated with festivals, traditions and cultural events are considered to be an integral part of Indian social life, which is always enriched with spectacular display of fireworks. Thus, fireworks play a vital part of religious celebrations, sporting events, political victories and New Year celebrations in the world. Many cultural and national celebrations such as Bastille Day in France, Guy Fawkes Night in the UK, Lantern festival in China and Taiwan, Diwali festival in India, Anzac Day celebration in Australia, Canada Day in Canada and Independence Day in the USA are celebrated with extensive and colourful fireworks displays. Widespread emissions of air pollutants released by fireworks can reduce visibility and significantly deteriorate air quality (Pope et al. 2016; Kong et al. 2015; Nasir and Brahmaiah 2015) in the fire bursting site and the neighbouring regions, which induces a direct impact on human health (Hamad et al. 2016; Seidel and Birnbaum 2015). The lightening of fireworks starts with an exothermic process engendering intense sound and smoke as a by-product holding gases like CO_2, CO, SO_2, NO, NO_2, VOCs, PM_{10} and $PM_{2.5}$ along with several metal salts such as aluminium, manganese, magnesium, strontium, barium copper, potassium and cadmium (Garg et al. 2018; Kumar et al. 2016; Singh et al. 2010). Nishanth et al. (2012) have classified a variety of hazardous organic compounds in the atmosphere during the fireworks associated with a south Indian festival of Vishu. Inhalation of trace metals

(Cd, Ni, Cr, Mn, Cu, etc.) released from fireworks results in severe health effects such as neurological, carcinogenic, lung diseases and haematological effects (Greven et al. 2019; Gouder and Montefort 2014; Barman et al. 2008).

Diwali (Deepavali) is a festival of light celebrated across India every year in the end of October or the first week of November with great enthusiasm by all sections of people. Detailed studies by various researchers on the widespread air quality changes caused by Diwali fireworks in north India have already been published (Saxena et al. 2020a; Singh et al. 2019; Peshin et al. 2017; Parkhi et al. 2016; Mandal et al. 2012; Pal et al. 2013; Chatterjee et al. 2013; Tiwari et al. 2012; Kulshrestha et al. 2004; Ravindra et al. 2003).

Firework display is an essential part of all festivals and celebrations, which usually attracts large crowds due to the spectacular display of colours in the sky. Even though it occurs in small duration, it is a potential source of air and sound pollution. Hence, short-term exposure to air pollution results in severe health issues. Since infants are more active in pyrotechnics, they are more prone to mortality from short-term exposure to elevated levels of air pollution (Greven et al. 2019). The oxidative potential of particulate matter, toxic gases and trace metals present in the emission plume of smoke makes fireworks an extreme event that changes the atmosphere in a short duration of time (Sonwani et al. 2021).

Vishu is celebrated as a regional New Year Day in Kerala State, which marks the commencement of agricultural activities. This festival is celebrated not only in Kerala but also in the border areas of the neighbouring states. Being the beginning of a New Year Day, it is often celebrated with extensive fireworks on 13 or 14 April throughout the state. Fireworks usually set off at home on the eve of Vishu from late evening to midnight and on the early morning of Vishu day. Thus, the intense fireworks in a short span create a terrifying smoke and dust in the atmosphere accompanied by extreme sound pollution. This smoke that spread during night time often produces a thick morning fog, which reduces the visibility. Moreover, black carbon dust and toxic gases present in this morning fog severely affect human health to a large extent (Saxena et al. 2020b). The interior of houses is generally contaminated with dust and pollutant gases emitted from the fireworks during night and early morning spells of the fireworks. As a result, inhaling dust and toxic gases in the whole night of Vishu can cause severe health issues, especially to infants and elderly people.

Research activities have been initiated in Kannur University to explore the chemistry of trace gases in a rural environment since 2009 with the support of ISRO and these activities and extended to Kannur town in 2019. This case study is an outcome of our long-term observation in the variations of trace pollutants such as surface O_3, NO, NO_2, CO, SO_2, BTEX and NH_3, PM_{10} and $PM_{2.5}$ at a residential site of Kannur town during the Vishu festival in 2020 and 2021. This work is a result of the air samples collected from 10 to 17 April in 2020 and 2021. We could not perform the qualitative and quantitative classifications of the organic compounds during fireworks, which is highly relevant.

11.2 Description of Monitoring Site

Kannur is the northern district of Kerala lying along the coastal belt of the Arabian Sea, which makes it one of the most popular tourist destinations in South India. The geographical coordinates are 11.87 N and 75.37 E, 3 m msl, which spans an area of 2961 km^2 with a population density of 852 per km^2. The map of Kannur is shown in Fig. 11.1a, and the outlook of Kannur town with the monitoring location is shown in Fig. 11.1b. Kannur town is an urbanized city having few industries including plywood, rub wood, mattress factories and handlooms in its neighbourhood areas. Agriculture and fisheries are the key sectors in the villages of this district. The monitoring station is installed close to the National Highway (NH 17), which has reasonably heavy traffic during the day and minimum at night. Further, it is surrounded by administrative buildings and residential areas and is about 2 km away from the Arabian Sea. Since the industries are quite far, transport-related activities, such as emissions from vehicular traffic, are major sources of various gaseous and particulate pollutants at this site.

Kannur is conferred with a pleasant climate throughout the year, due to the proximity of Arabian Sea in the west and the Western Ghats in the east. Relatively higher temperatures, low rainfall and a faintly humid climate are the main features of the summer season in Kerala. Measurements of trace pollutants were carried out using the respective ground-based gas analyzers from Environment S.A France. Detailed description of the instruments used for the study is reported in our previous publication (Resmi et al. 2020).

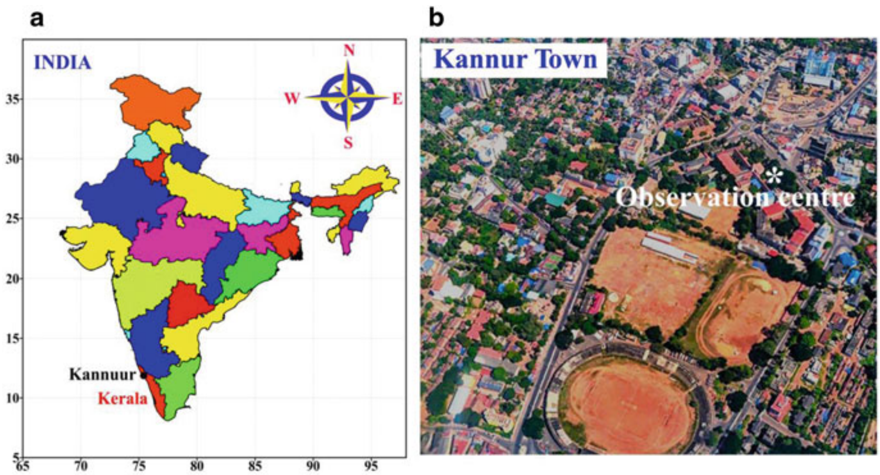

Fig. 11.1 (**a**) Kannur in South India (**b**) airborne vision of Kannur town and the monitoring station

11.3 Results and Discussion

11.3.1 Variation of Surface O_3

In order to investigate the effect of fireworks on the concentrations of trace pollutants over Kannur town, the study retro is divided into three four, viz. pre-Vishu days (10, 11, 12 April), day before Vishu (13 April), Vishu day (14 April) and post-Vishu days (15, 16 17 April). Figure 11.2 shows the 24-h variation of O_3 over the monitoring station for the study period days during 2020 and 2021. It is found that the diurnal variation of O_3 during these 2 years exhibited a similar profile with different amplitudes. On a diurnal basis, O_3 concentration usually starts to increase in-tune with solar radiation from the morning hours and reaches its maximum level at noontime hours. Then, it exhibits a declining phase in afternoon hours and reaches its low level during the late evening and night hours. The high concentration of O_3 observed in the daytime is primarily due to the enhanced VOC-NOx chemistry in the presence of intense solar radiation. During night-time hours, photochemical production becomes weak and O_3 titration with NO is more pronounced, which leads to a decrease in O_3 concentration. However, no significant change in ozone has been noticed in 2020 as the fire bursting has been banned in the wake of country wide lockdown.

In 2021, O_3 concentrations show a momentous increase on the eve (18:00–22:00 h) of Vishu day and the early morning (04:00–10:00 h) of Vishu day due to intense fire bursting over the observational site. Thus, just after the fire bursting, O_3 concentration enhanced from ~19.2 ppbv to ~29.0 ppbv (an upsurge of 51%) in the evening spell on the eve of Vishu day and from ~11.4 ppbv to ~18.4 ppbv (an increase of 61%) on the early morning spell on Vishu day. Surface O_3 is usually formed only in daytime by the photodissociation of NO_2 in the presence of sunlight ($\lambda < 420$ nm). Thus, in a closed state, the following set of reactions shows a production and dissociation of O_3 (Seinfeld and Pandis 2006).

$$NO_2 \rightarrow NO + O \tag{R11.1}$$

$$O + O_2 + M \rightarrow O_3 + M \tag{R11.2}$$

$$NO + O_3 \rightarrow NO_2 + O_2 \tag{R11.3}$$

The exciting feature of our measurement is the upsurge in O_3 level during the evening and early morning spells of Vishu even in the lack of solar radiation. This growth is connected with fire bursting that occurred in two spells of 2021. Accordingly, the O_3 produced during this episode was mainly at the expense of firecrackers. The additional NO_2 essential for the upsurge of O_3 was produced from the fire bursting event.

$$NO + HO_2 \rightarrow NO_2 + OH \tag{R11.4}$$

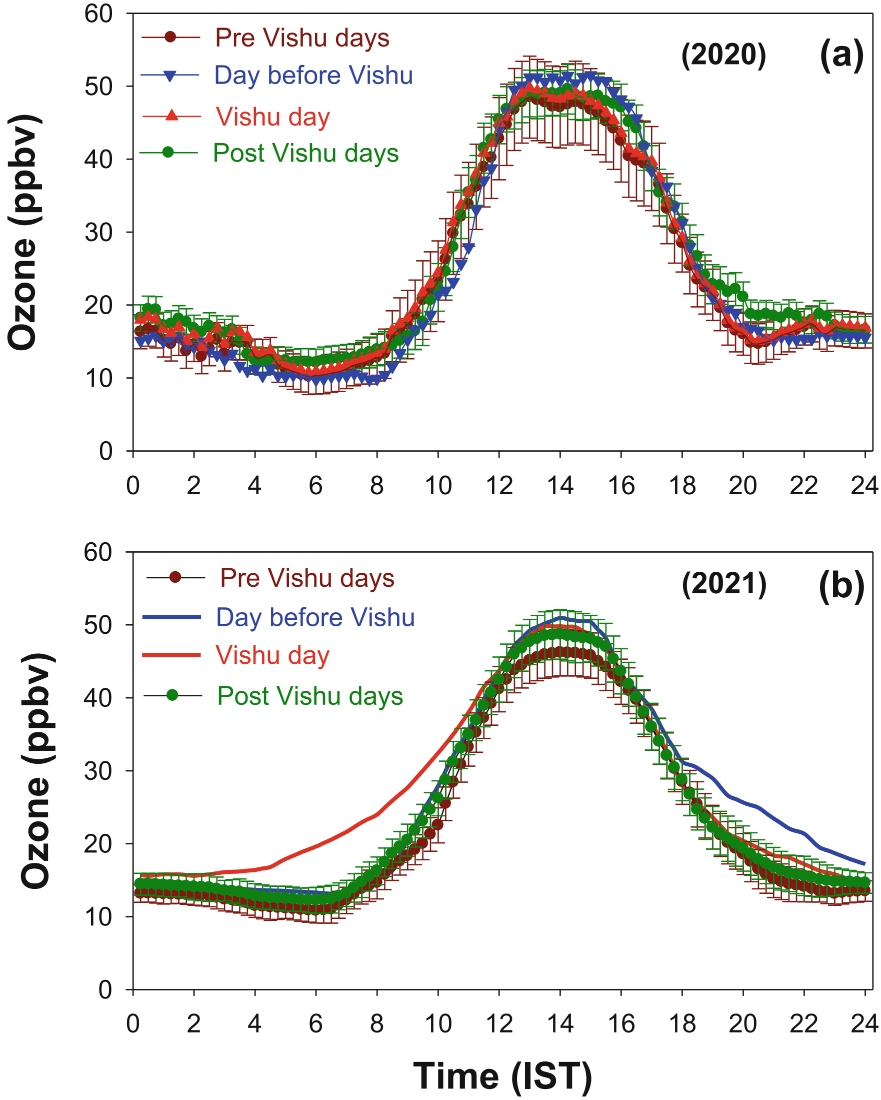

Fig. 11.2 Variation of surface O_3 during the study period in (**a**) 2020 and (**b**) 2021

$$NO + RO_2 \rightarrow NO_2 + RO \qquad \text{(R11.5)}$$

Thus, night-time O_3 enhancement is by the photolysis of NO_2 present in the smoke activated by intense flash of the fireworks.

11.3.2 Variation of Oxides of Nitrogen

Variation of NO and NO_2 in the days of observation in 2020 and 2021 is shown in Fig. 11.3a–d. The diurnal profiles of NO and NO_2 show higher concentrations in the morning and late evening hours and low concentrations during daytime hours. The enhancement in the concentrations of NO and NO_2 during the morning and late evening hours is due to vehicular exhaust and shallow boundary layer height. Soon after sunrise, peroxyacetyl nitrate (PAN) breaks into NO and NO in the presence of sunlight interacts quickly with O_3 or O_2 to form NO_2 due to its short lifetime (Wang et al. 2019). Subsequently, NO_2 undergoes photolysis in the presence of sunlight to form NO and atomic oxygen, which combines with molecular oxygen produces surface O_3 indicated by reactions R1 and R2. After the maximum concentration observed in the morning, NO_2 starts declining until it extends its lowest concentration between 14:00 and 16:00 h, and then reaches a steady upturn until late-night hours. The main reason behind the decline of NO_2 during day time is due to the increased photolysis by intense solar radiation. Thus, this decrease in NO_2 concentration is at the expense of photochemical production of surface O_3 in the presence of intense solar flux. The night-time concentration of NO and NO_2 shows a gradual increase from 19:00 h to midnight on 13 April 2021.

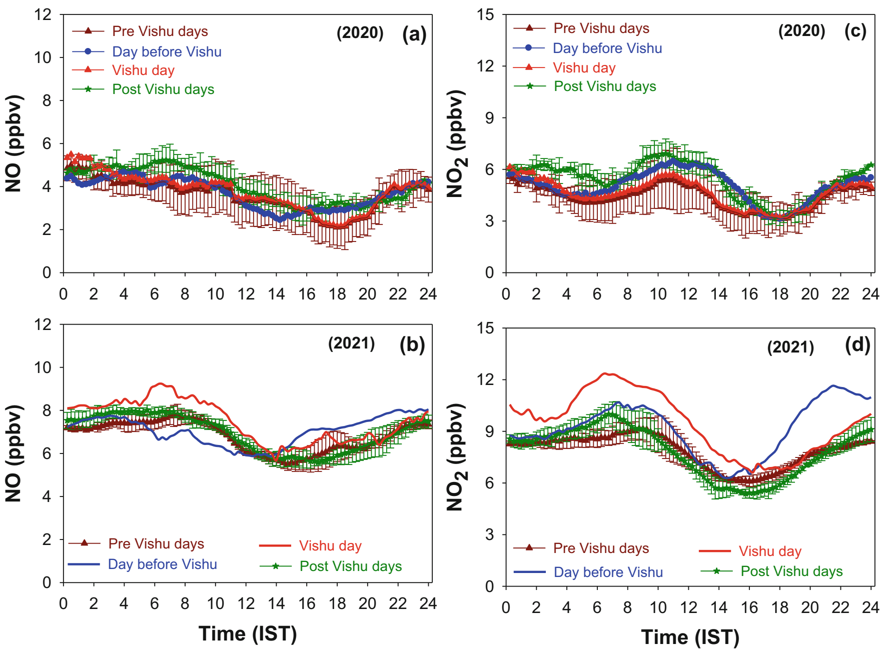

Fig. 11.3 Diurnal variation of NO during the study period in (**a**) 2020 and (**b**) 2021 and NO_2 during the study period in (**c**) 2020 and (**d**) 2021

In this festival episode, NO concentration also exhibits a small increase from ~6.2 ppbv to ~7.8 ppbv (an upsurge of 26%) observed in the evening spell on the eve of Vishu and from ~7.1 ppbv to ~9.4 ppbv (an upsurge of 32%) on the early morning spell on Vishu day. Surprisingly, the concentration of NO_2 enhances from ~7.5 ppbv to ~11.6 ppbv (an increase of 56%) in the evening spell on the eve of Vishu and from ~8.1 ppbv to ~12.4 ppbv (an upsurge of 53%) on the early morning spell on Vishu day. This shows an increase in NO and NO_2 concentrations in the evening and the early morning spell only in 2021 due to the lockdown imposed in 2020.

11.3.3 Variation of CO and SO_2

Figure 11.4a, b shows the diurnal variations of CO during pre-, post- and Vishu days in 2020 and 2021 at Kannur town. Diurnal variation of CO displayed two peaks in morning and evening due to traffic hours in the town. Usually, the morning and evening peaks are observed at 08:00–10:00 h and 17:00–20:00 h in this location. Various groups in India have reported a similar variation of CO in many urban areas (Beig et al. 2007; Mahapatra et al. 2014; Verma et al. 2017; Resmi et al. 2020). Generally, during pre- and post-Vishu days, the observed concentration of CO varies from 340 to 680 ppbv and an increase (62%) in CO concentration is noticed from the beginning (540 ppbv) of fire bursting on the evening spell on the eve of Vishu day

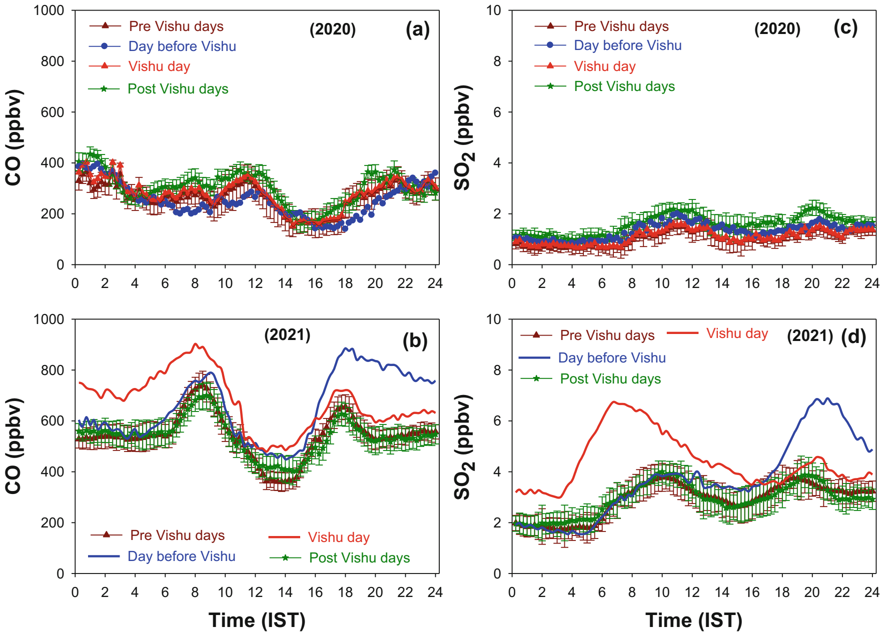

Fig. 11.4 Diurnal variation of CO during the study period in (**a**) 2020 and (**b**) 2021 and SO_2 during the study period in (**c**) 2020 and (**d**) 2021

and it reaches a maximum value (850–882 ppbv) during 19:00–20:00 h. Likewise, during the early morning on the Vishu day, the concentration of CO shows an upsurge of 72% and attains a maximum value (840–890 ppbv) between 06:00 and 08:00 h with respect to the pre-Vishu concentration of 520–540 ppbv. Further, its concentration is observed to be high during the evening on Vishu day with respect to pre-Vishu days, which account for the bursting of fireworks in the surroundings of the observational site.

The diurnal variations of SO_2 during pre-, post- and Vishu days in 2020 and 2021 at Kannur town are shown in Fig. 11.4c, d. The primary source of SO_2 at the observational site is from vehicles after the combustion of sulphur present in diesel. During daytime, the anthropogenic activities (such as vehicular and industrial actions, and biomass burning) contribute fairly large release of SO_2 in the lower atmosphere and it remains gas-phase SO_2 in night-time hours. The diurnal variation of SO_2 exhibited two distinct peaks during morning (9:00–11:00 h) and evening (19:00–22:00 h) of the pre- and post-Vishu days, and it varies from 1.7 ± 0.41 to 3.8 ± 0.52 ppbv. Just after the fire bursting, SO_2 concentration enhances from ~3.52 ppbv to ~6.88 ppbv (an increase of 96%) in the evening spell on the eve of Vishu day and from ~2.4 ppbv to ~5.8 ppbv (an increase of 142%) on the early morning spell on Vishu day.

11.3.4 Diurnal Variation of BTEX and NH_3

Benzene, toluene, ethylbenzene and xylene (BTEX) are the main hydrocarbons found in the lower atmosphere in the group of volatile organic compounds (VOCs). Figure 11.5a, b shows the diurnal variation of BTEX and during pre-, post- and Vishu days in 2020 and 2021 at Kannur town. BTEX shows a pronounced enhancement in the morning, and evening hours and low in noontime hours. Daytime and nocturnal concentrations of BTEX exhibit a considerable increase during fire bursting episode in 2021 over Kannur town. BTEX concentration enhances from ~6.3 ppbv to ~12.1 ppbv (an increase of 92%) in the evening spell on the eve of Vishu day and from ~5.5 ppbv to ~11.3 ppbv (an increase of 105%) on the early morning spell on Vishu day.

Figure 11.5c, d describes the 24-h variation of NH_3 during pre-, post- and Vishu days in 2020 and 2021 at Kannur town. NH_3 shows a progressive deviation with higher concentrations during daytime hours due to the anthropogenic activities and a build-up of pollutants by low wind speeds (Kuttippurath et al. 2020; Behera et al. 2013). During pre- and post-Vishu days, the mixing ratios of NH_3 vary from 4.65 ± 0.42 to 5.88 ± 0.48 ppbv on a diurnal basis. The concentration of NH_3 starts increasing from 5.25 ppbv at the beginning of the fire bursting and reaches its maximum level of 5.88 ppbv with an upsurge of 12% in pre-Vishu days. Quite similar to this, on the Vishu day, the concentration of NH_3 increases from 5.02 ppbv to 5.75 ppbv with an increase of 15%. Despite the fire bursting activity is reduced considerably after the morning of 14 April on Vishu day, the concentrations of trace gases except BTEX and NH_3 remain higher level compared to post-Vishu days.

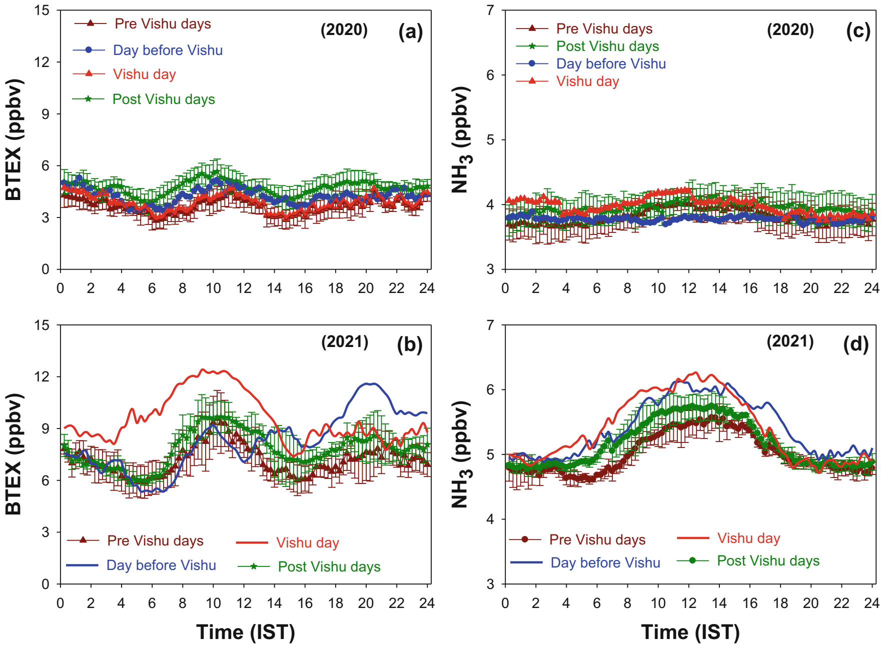

Fig. 11.5 Diurnal variation of BTEX during the study period in (**a**) 2020 and (**b**) 2021 and NH_3 during the study period in (**c**) 2020 and (**d**) 2021

11.3.5 Variation of PM_{10} and $PM_{2.5}$

Particulate matter is formed by a cluster of small and large particles of different chemical configurations, and it consists of both fine ($PM_{2.5}$) and coarse (PM_{10}) modes of airborne particles (Pakbin et al. 2010). The fine mode particles are formed by burning or gas-to-particle conversions and are rich in carbon, sulphates, ammonium and nitrate ions, as well as trace elements (Liu et al. 2015). The anthropogenic emissions of trace gases and particulate matter thus exert a significant influence on the chemistry and radiative balance of the local urban environment. Further, it influences the regional production of surface O_3 and OH radicals affecting the urban air quality. Diurnal variations of PM_{10} and $PM_{2.5}$ observed in 2020 and 2021 are shown in Fig. 11.6a–d. In 2021, PM_{10} and $PM_{2.5}$ show higher concentrations during morning (09:00 to 12:00 IST) and evening (16:00 to 20:00) hours due to the crowning traffic and late-night hours due to the accumulation of pollutants by shallow boundary layer. After morning enhancement between 07:00 and 10:00 h, the concentrations of particulate matter gradually decrease until 15:00 h due to the diffusion of pollutants by broadened boundary layer height in the presence of intense solar radiation (Qu et al. 2017).

An increase in concentration of PM_{10} and $PM_{2.5}$ is noticed from the beginning of fire bursting on the eve of Vishu day and the early morning on the Vishu day. Just

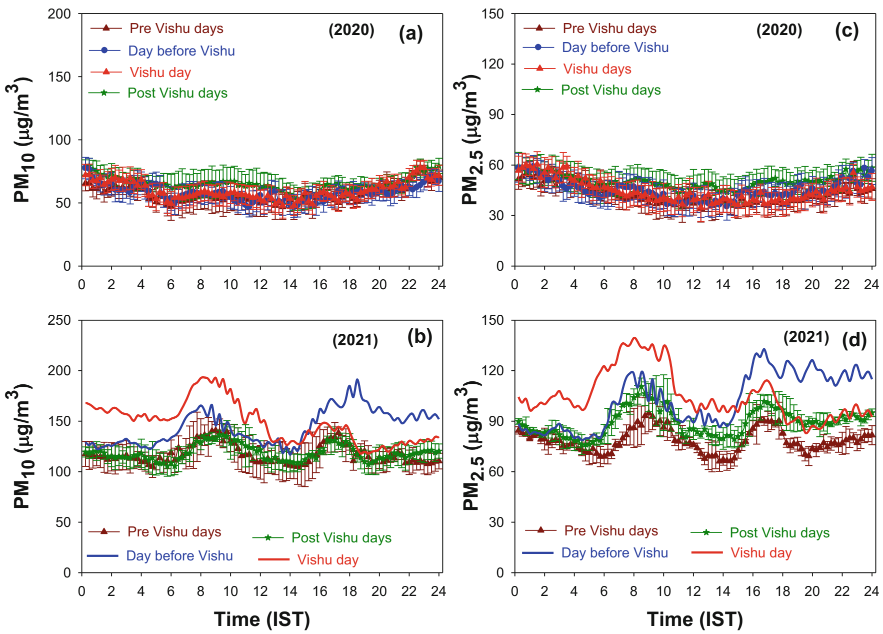

Fig. 11.6 Diurnal variation of PM_{10} during the study period in (**a**) 2020 and (**b**) 2021 and $PM_{2.5}$ during the study period in (**c**) 2020 and (**d**) 2021

after the fire bursting, PM_{10} concentration enhances from ~110 μg/m^3 to ~191 μg/m^3 (an upsurge of 74%) in the evening spell on the eve of Vishu day and from ~108 μg/m ^{3} to ~195 μg/m^3 (an increase of 81%) on the early morning spell on Vishu day. Likewise, an increase in concentration of $PM_{2.5}$ is observed from the beginning of fire bursting on the evening spell on 13 April and morning spell on 14 April 2021. Likewise, mounting levels of $PM_{2.5}$ are observed from ~84 μg/m^3 to ~135 μg/m^3 (an increase of 61%) in the evening spell on the eve of Vishu day and from ~75 μg/m^3 to ~140 μg/m^3 (an increase of 87%) on the early morning spell on Vishu day.

11.3.6 Variation of Metal Concentrations Associated with Particulate Matters

The present study extended to monitor the concentration of various inorganic elements present in the ambient air of Kannur town during the observation days in 2021. Beni and Esmaeili (2020); Jan et al. (2015) have reported the adverse effect of metals contained in particulate matter on the respiratory tract of human beings due to their bio-accumulative and poisonous nature in the environment. World Health Organization (WHO 2016) that included PM_{10} containing Pb, Ni, Co, Cd and As is a prominent air pollutant. Exposure to high levels of Pb and Mn can lead to severe neurotoxic and haematological effects in children, and Ni, Cd and Cr cause

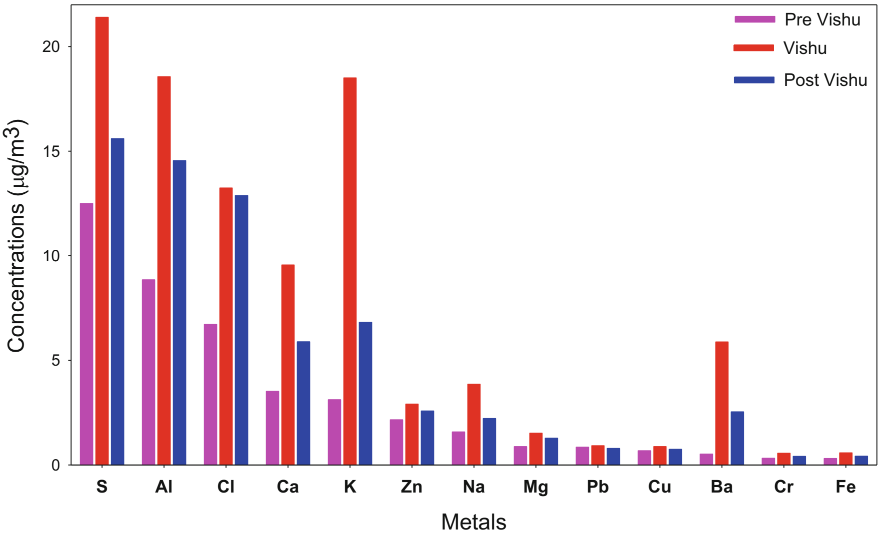

Fig. 11.7 Concentration of metals present in ambient air during pre-, post- and Vishu days

oncogenic effects in humans (Shen et al. 2018; Singh et al. 2011). In order to study the metal concentrations bounded with the particulate matter, PM_{10} in the ambient air on the observational days is collected using a high-volume air sampler located on the roof in the monitoring station. The concentration of metals associated with PM_{10} during pre-Vishu, Vishu and post-Vishu days is shown graphically in Fig. 11.7.

It is observed that metal concentrations are found to be higher in Vishu days than pre- and post-Vishu days. The average concentration of metals shows in the order S > Al > Cl > Ca > K > Zn > Na > Mg > Pb > Cu > Ba > Cr > Fe > Ni > Sr > Mn. Based on the concentrations, major upsurge is observed for seven metal species in PM_{10} samples (S, Al, Cl, Ca, K, Zn and Na) on Vishu day compared to samples from pre- and post-Vishu days. A similar enhancement in metal species has been observed by different groups across the globe (Shivani et al. 2020; Pervez et al. 2016; Tsai et al. 2012; Perrino et al. 2011). Generally, all the firecrackers contain potassium nitrate, potassium chlorates and potassium perchlorates in the form of a black powder, which acts as a combustible material (Moreno et al. 2007). Sulphur (S) is used as a propellant, whereas aluminium (Al) and copper (Cu) are used for colour displays and sparklers, while sodium (Na) was commonly used as metal oxidizer (Pervez et al. 2016; Tandon et al. 2008).

11.4 Conclusion

Colourful fireworks display is one of the main attractions of festival seasons. The south Indian state of Kerala celebrates Vishu, which earmarks the regional New Year, which falls in the middle of April month every year. This festival usually starts in the evening of Vishu eve with coordinated fireworks set up to late night and resume in the early morning of Vishu day with two distinct spells of fire bursting episodes. Our observations were conducted on trace gases in 2020 and 2021, and it is further observed that the concentrations of all trace gases remain unchanged due to the ban of fireworks in the wake of strict lockdown. The observations in 2021 reveal the increase in O_3 concentration from 19.2 ppbv to 29.0 ppbv on the evening spell on the eve of Vishu day and from 11.4 ppbv to 18.4 ppbv on the morning spell of Vishu day. The concentration of NO increases from its value of ~6.2 ppbv to ~7.8 ppbv on the evening spell on the eve of Vishu day and from ~7.1 ppbv to ~9.4 ppbv on the morning spell of Vishu day. The abundance of NO_2 shows a clear upsurge of 4.1 ppbv on the evening spell on the eve of Vishu day and 4.3 ppbv in the morning spell for the year 2021. A sharp increase in CO concentration was observed during the evening spell (62%) and morning spell (72%) of firework event. The observed SO_2 concentration enhanced to 96% on evening spell and 142% to early morning spell for the year 2021. The concentration of BTEX increased from its value of ~6.3 ppbv just after the fire bursting to ~12.1 ppbv on evening spell and from ~5.5 ppbv to ~11.3 ppbv on early morning spell of Vishu day. NH_3 shows an enhancement of 12% in the evening spell and 15% in the morning spell of Vishu day. Mixing ratios of PM_{10} increase in the evening spell in Vishu eve from 110 μg/m^3 to 191 μg/m^3, and in the morning spell of Vishu day, it is from 108 μg/m^3 to195 μg/m^3. Similarly, the concentration of $PM_{2.5}$ is found to increase from 84 μg/m^3 to 135 μg/m^3 in the evening spell in Vishu eve and vary from 75 μg/m^3 to140 μg/m^3 in the morning spell of Vishu day. All metal concentrations associated with particulate matters are found to be much higher during Vishu days than pre- and post-Vishu days.

The Indian festivals are the reflections of the vast cultural diversity in the country, and all festivals are becoming colourful, which are being celebrated with much enthusiasm. The common feature of all festivals is an extensive firework display at the end of the festivals. The use of firecrackers in festivals and celebrations in Kerala has been alarmingly increasing in every year. On the day of Vishu, it is a joyful experience to witness the spectacular wonders of the firecrackers in the sky over each house. Such type of celebrations enhances the concentrations of trace gases and particulate matter in the atmosphere, leading to serious health problems. Celebrations employing fireworks in India have not yet been legally restricted except in the lockdown periods. Instead of legally banning such activities, the use of fireworks in celebrations and festivals can be curtailed to some extent once the public is made aware of the harmful effects of fireworks. Thus, a public awareness of the air and sound pollutions of fireworks may be created to discuss on the severity of this man-made environmental threat through the media in order to save our environment.

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