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TEMPORAL VARIATION IN INDOOR AIR QUALITY DURING FESTIVAL OF FIREWORKS IN INDIA

R.B. Soni [1,*] and R. Dhankhar[2]
[1]Department of Environment Science, Vaish College of Engg. Rohtak(Haryana), India
[2]Department of Environment Science, Maharishi Dayanand University, Rohtak (Haryana), India
*E-mail: rajenv2009@gmail.com

ABSTRACT
Diwali is great festival of India and it celebrated with full enthusiasm by Indian. But during this festival there is excessive use of fireworks which relate to short term variation in indoor air quality as well as outdoor concentration of pollutants which mainly affects the health of human beings. The present study aimed to estimate the concentration of PM10, SO_2, NO_x by measuring through AAS-127 Pm10 and AAS-118 Gaseous Sampler. For determine the Indoor air quality during Diwali two sites were selected on based of types of fuel used for cooking (Biomass Based site-1) and (LPG Based site-II). The average concentration of indoor pollutants PM10, NO_X, SO_2 on day of Diwali was 48.2 µg/m^3, 87.65µg/m^3,45.06 µg/m^3 for site-1 and 28.46 µg/m^3, 56.09 µg/m^3, 38.9 µg/m^3 for site-II was observed and it was 2 times and 2.5 times higher than the indoor concentration on normal day. The order of concentration on Diwali night NO_X> PM10 >SO_2 with pattern of post Diwali day> Diwali> pre Diwali while outdoor concentration of pollutants on post Diwali day was observed to be higher than the pre Diwali day which indicates a longer time stay of these pollutants in outdoor air, which accumulate on Diwali night due to fireworks.
Keywords: Indoor pollutants, Diwali festival, Atomic Absorption Spectroscopy.

INTRODUCTION

After rapid industrialization and urbanization indoor air quality has becomes the challenge for all developing and developed countries. Indoor air pollution is biggest killer than outdoor air pollution in India. About 1.3 million people died by indoor air pollution in 2010 while due to outdoor air pollution death was approximate 6.20 lakh. Indoor air pollution now consider as major human health concern. Indoor air pollution (IAP) is mainly due to indoor activities and outdoor pollution .In India indoor air pollution is second biggest killer after high blood pressure. India does not have any norms for indoor air pollution, which mandates emission norms for home appliances such as refrigerators, air-conditioners and bread toasters and a limit beyond which dirty air inside homes can be bad for one's health. World Health Organization (WHO) has prescribed 20 micro grams in cubic meter (µg/m^3) of air for particulate matter as a norm for indoor air pollution. In India, the average indoor air pollution is 375 µg/m^3 and the prime contributor for this is burning of solid fuels.

More than half the world population in developing countries is still rely on biomass for their daily indeed and the combustion of biomass fuels in poorly ventilated kitchen leads to release of high concentration of respirable particulates and gases CO, SO_2, NO_x with toxic compounds benzene, formaldehyde and polycyclic aromatic compounds (benzopyrene) and indoor kitchen is the biggest Kitchen.[1] During festival time there is effect on urban air and noise quality also effected[2]. In urban areas, there are other reasons like the poor sanitation, generation of solid wastes and open landfilling, with inadequate housing, lack of awareness regarding toxicity of air pollutants causes the ill health effect of women and children [3-5] observed the indoor activities and poor ventilation qualities are responsible for high level of indoor RSPM and PAHs in rural homes in India. Indoor air quality is also interacted and affected by the local outdoor air with specific building characteristics and indoor activities[6.] Indoor pollutants emissions originate not only from building materials or furnishing, but it is also from common household activities such as cooking, smoking and burning of incense and candles[7-8] and also from various consumer products which people use at their homes in their day to day activities. During festival season, there is major problem of indoor pollution and Diwali is the religious festivals of India. On this day people use crackers in competitive manners which fades the craze of Diwali. By the excessive use of crackers and firework the carcinogenic health effect is there due to inhalation of PM 2.5[9]. Large-scale fireworks during Diwali leads to increase the levels of ambient atmospheric particulates and gases like sulfur dioxide (SO_2), carbon dioxide (CO_2), carbon monoxide (CO), suspended particles (including particles below 10µm in diameter, i.e., PM10) which are associated with serious health hazards[10]. Maximum number of quantity of crackers and sparkles are burnt mainly on Diwali day followed by day before Diwali and day after Diwali. In order to determine the effects of fireworks on concentration of PM10 (8hrs or 1hrs depend on concentration), SO_2 and NOx (4hrs/1hr) by continuous monitoring was conducted in different areas of Rohtak city during Diwali festival (November, 2014).

EXPERIMENTAL

Methodology

Rohtak is the city of Haryana state and it is situated in the northern region of India. Rohtak lies between 28.89º north latitude and 76.57 º east longitudes. Average annual rainfall in Rohtak city is 458.5mm. Two sites (Site-I biomass based kitchen, Site- II LPG based kitchen) of Rohtak city was undertaken to determine the status of indoor air quality. Present study is to determine the sulphur dioxide (SO_2), nitrogen dioxide (NO_x) and particulate matter (PM10) present in homes under different locations during Diwali festival with the help of respirable and gaseous dust sampler.

Sampling and Analysis

AAS-127 Pm 10/Pm2.5 Sampler was used for measuring the concentrations of PM10 and AAS -118 Gaseous Sampler was used for measuring concentration of NO_x and SO_2 in the air at a flow rate of 1.0 ltr./min for 4hrs during daytime (6.0 a.m.–6.0 p.m.) and night time (6.0 p.m.–6.0 a.m.). The sampling equipment was placed at standard height from the ground level. Pre-weighed quartz microfiber filter papers, Whatman (QMA) of 20 × 25 cm2 sizes were used and reweighed after sampling in order to determine the mass of the particles collected. The experiments were performed during November for covering the concentration of pollutants on festival of Diwali. A known quantity of air was passed through the impinger containing known volume of absorbing solution, and the flow rate of the impinger was set at 1 l/min. SO_2 was analyzed by the West–Gaeke method and NO_2 was analyzed by the Jacob–Hochheiser modified method while PM10 was analyzed by gravity based method.

RESULTS AND DISCUSSION

SITE-1: Kitchen based on Biomass

Concentration of PM10

On pre-Diwali, Diwali and on post-Diwali the day-time and night time concentrations of PM10 aerosols have been observed and their correlation coefficient value (R^2) has been calculated in Figure -1. The night-time concentrations of PM10 on pre-Diwali, Diwali and post-Diwali day were 1.5 times, 2 times and 2.5 times higher than the normal day's night time. This is due to increase in mixing height with low in temperature which allows the particles to be accumulated near the surface.

Concentration of SO_2

Normally, average day and night-time concentrations of SO_2 were found to be almost equal on normal day. During day-time, the anthropogenic activities (fossil fuel burning, from vehicular and industrial activities, biomass burning) are higher resulting higher emission of SO_2 than night-time). SO_2 concentrations were 1.5 times, 2 times and 1 times higher on pre-Diwali, Diwali and post-Diwali night respectively than that during the respective periods on normal day and their correlation coefficient value(R^2) has been calculated given in (Figure-2).

Concentration of O_X

The night-time concentrations of NO_X were higher than day-time on festival days (pre-Diwali, Diwali and post-Diwali). NO_X concentrations were 1.6, 5 and 3.7 times higher on pre-Diwali, Diwali and post-Diwali night respectively than that on normal day and the effect of firework activities and correlation coefficient value(R^2) has been calculated given in (Figure-3).

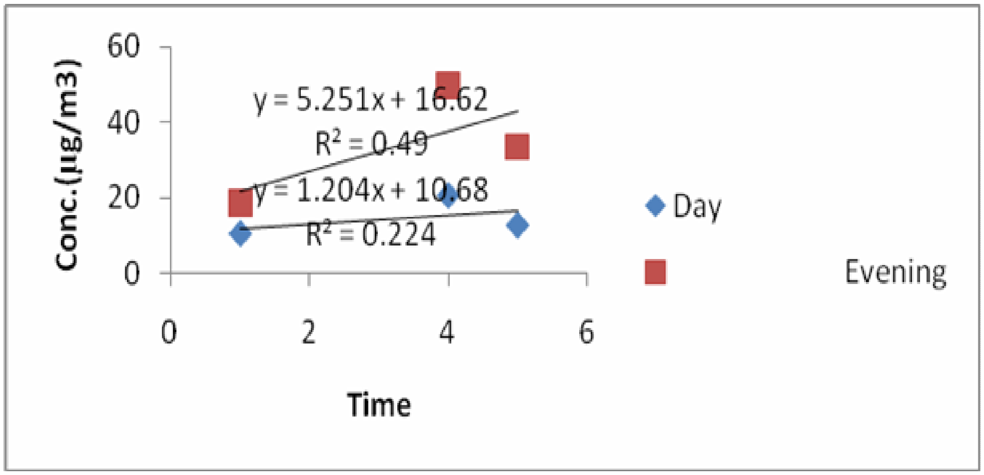

Fig.-1

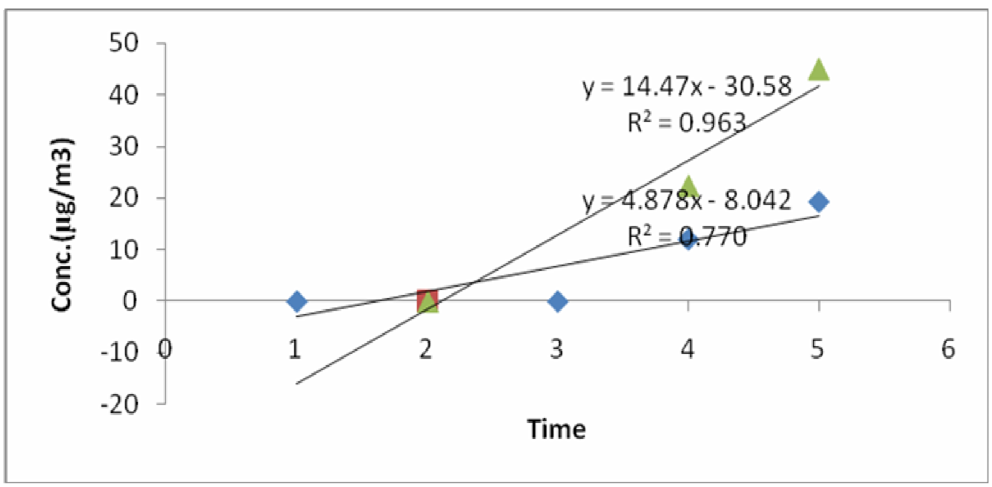

Fig.-2

SITE-2: Kitchen based on LPG

Concentration of PM10

During day-time and night time concentrations of PM10 in homes have been observed during pre-Diwali, Diwali and post-Diwali day have been shown in Figure-3. The night-time concentrations of PM10 in indoor homes on pre-Diwali, Diwali and post-Diwali day were approximately 1.2 times, 2 times and 1.5 times higher than normal day concentration and value of correlation coefficient value (R^2) has been given in (Figure-4). It is to be noted that maximum firework activities occurred on Diwali-night followed by post-Diwali-night and pre-Diwali-night. Thus, it is clear that there was a strong effect of night-time firework activities on the next day day-time aerosol concentration.

Concentration of SO_X

The night-time concentrations of SO_2 were higher than day-time concentrations on festival days (pre-Diwali, Diwali and post-Diwali and which was 1.5 times higher than normal day night-time) on post-

Diwali day which was ~1.2 times higher than normal day night-time) and pre-Diwali day which was ~1 times higher than normal day night-time and R^2 value has been calculated in Figure-5).

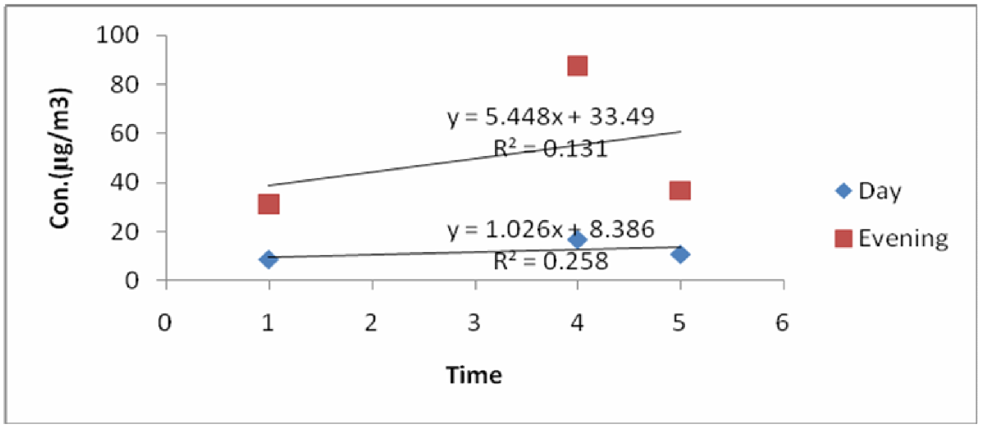

Fig.-3

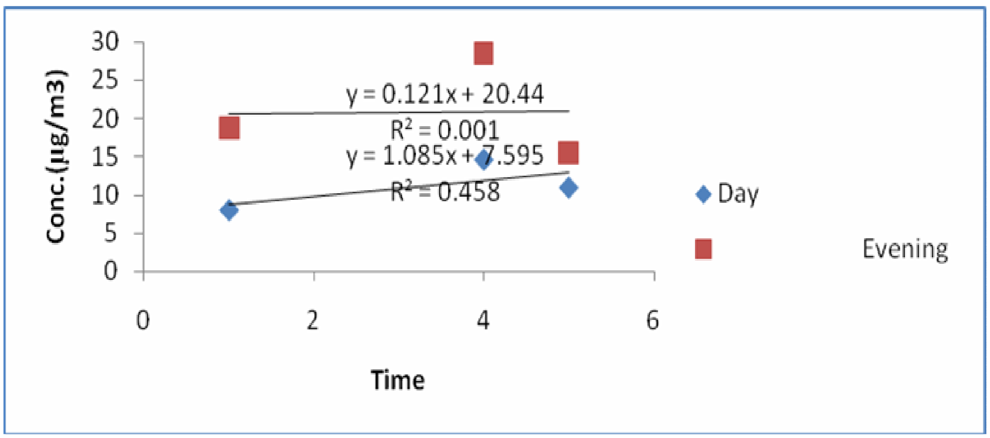

Fig.-4

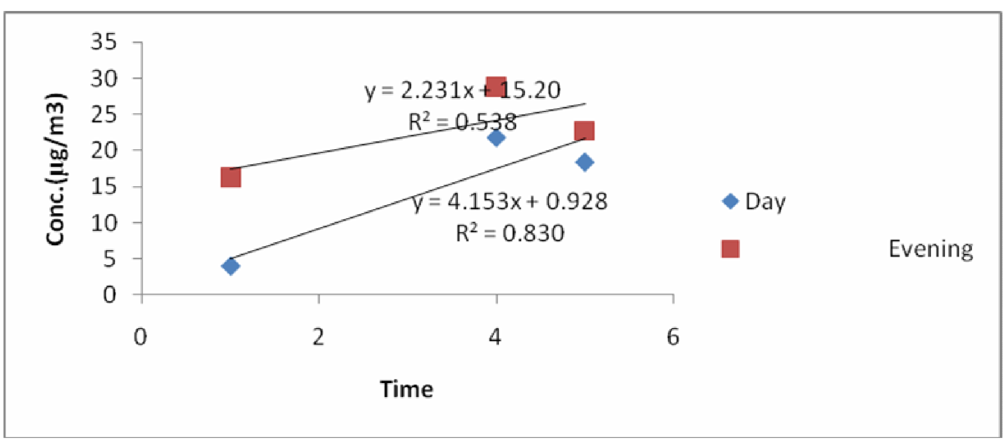

Fig.-5

Concentration of NO_X

The night-time concentrations of NO_X were higher than day-time concentrations on festival days (pre-Diwali, Diwali and post-Diwali). The maximum night-time concentration was observed on Diwali day which was ~2.5 times higher than normal day night-time) followed by post-Diwali day which was ~1.5 times higher than normal day night-time) and pre-Diwali day which was almost equal than normal day night-time) and their value of R^2 has been calculated in Figure No.6. The effect of firework activities during Diwali night on early morning hours on post-Diwali day was found to be higher than the effect of pre-Diwali night on early morning hours on Diwali day and average variations of corresponding pollutant levels on Diwali.

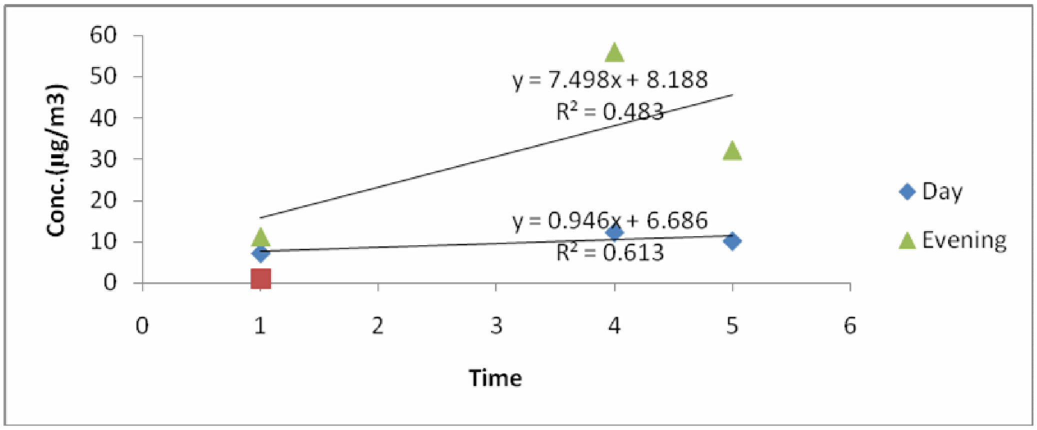

Fig.-6

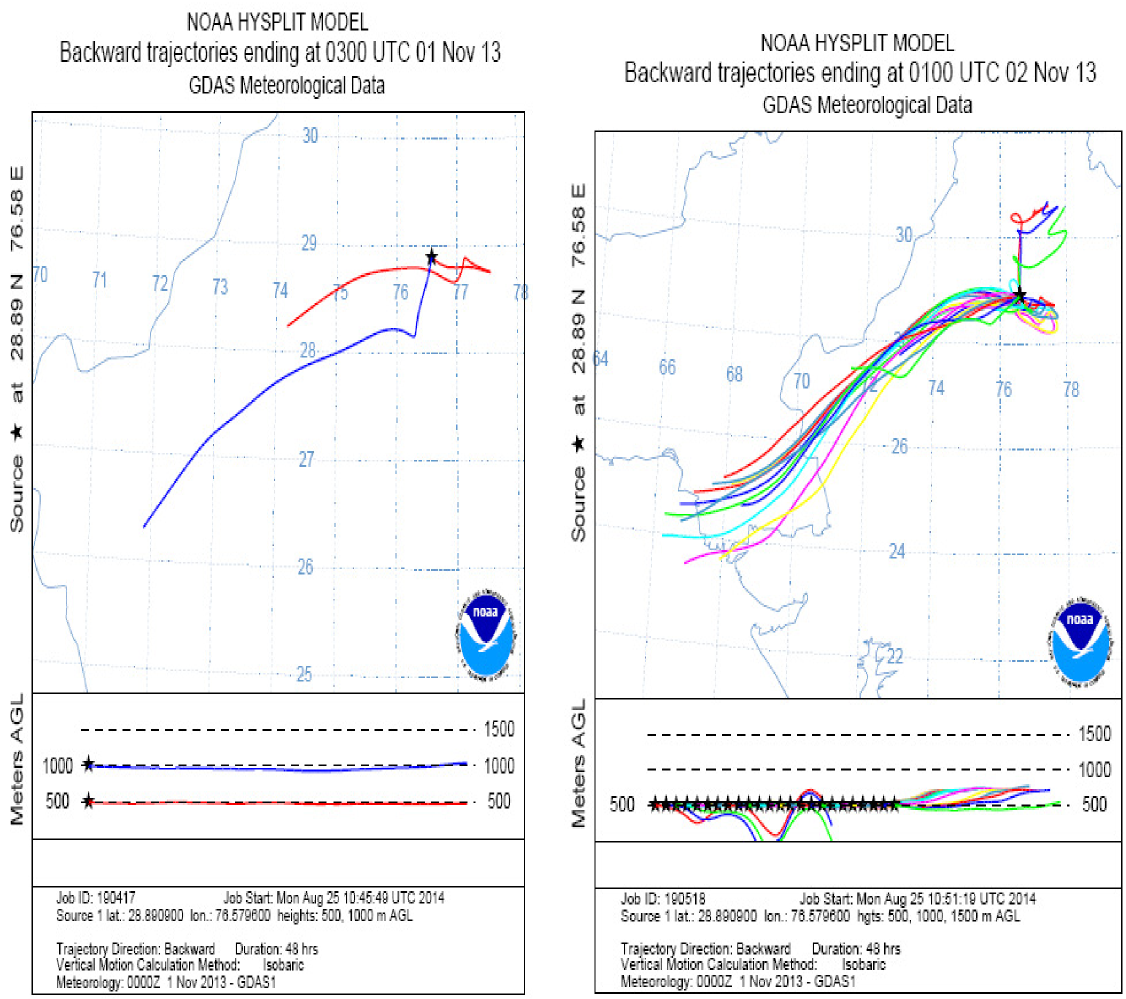

Fig.-7: The typical air mass trajectories arriving at sampling site - Backward trajectory pointing to the dust source from northwest Asian desert on 1st and 2nd November 2013 (Day before Diwali)

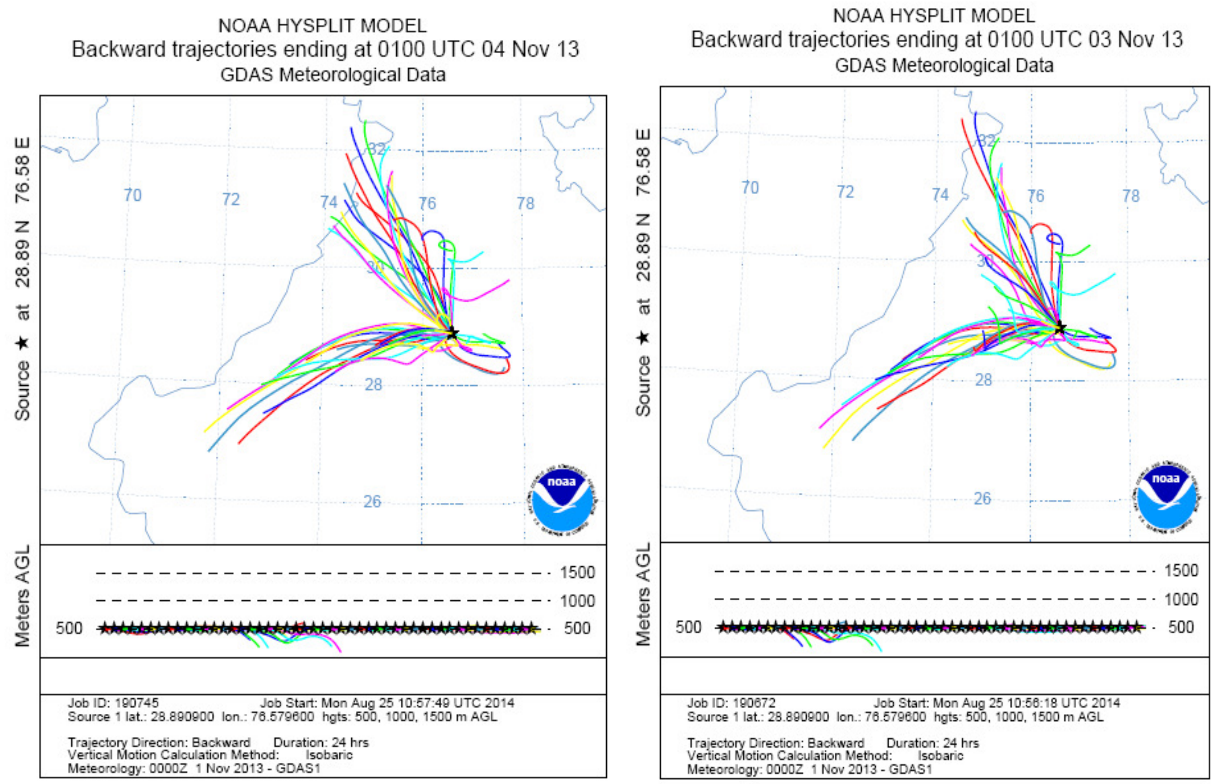

Fig.-8: The typical air mass trajectories arriving at sampling site - Backward trajectory pointing to the dust source from northwest Asian desert on 3rd and 4th November 2013 (Day before Diwali)

Concentration of PM10, SO_2, NO_X in Outdoor

In November average concentration of PM10 was 155.10 µg/m^3, NO_x was 86.08 µg/m^{3}and SO_2 concentration was 8.04 µg/m^3 while maximum average concentration of PM10 was 242.13 µg/m^3, NO_x was 186.07 µg/m^3 and concentration of SO_2 was 21.89 µg/m^3. On Diwali, average concentration of PM10 was 46.92 µg/m^3, NO_x was 158.73 µg/m^3 and SO_2 was 11.00 µg/m^3 concentration of SO_2 noted through Continuous Ambient Air Quality Monitoring Report.

Air Mass Back Trajectory Analysis

The possible transport pathways of atmospheric constituents of trace gases and atmospheric aerosols are often examined by Lagrangian-based particle trajectory models. These back trajectories are primarily calculated from the observed wind and pressure fields. These have been often used as the basis for O_3 climatologists. In the present study, back trajectories are calculated using the Air Resources Laboratory's HYSPLIT model. NOAA-HYSPLIT wind back trajectory was computed hourly for 72 h (3 days). Figure shows the NOAA-HYSPLIT wind back trajectories on Diwali days. A close examination of these trajectories demonstrated that all the air masses have their origin over the north of the study site. However, it has been shown in Figures-5 and 6, that there was no forest fires/biomass burning on present study region. Hence, the increases in atmospheric pollutants were attributed to the Diwali fireworks episode.

CONCLUSION

The present study investigates the impact of Diwali fireworks episodes on indoor air quality of Rohtak of month of November, 2013. The enhanced NO_x concentration in the presence of visible radiation due to firecrackers burning during the Diwali festivity period favored night time production of O_3 even in the absence of photochemical reactions. The NO_x concentration 1.5 times showed an average increase and

SO_2 concentration also followed one fold increases on Diwali day as compared to control days at site 1 while NO_x concentration is twice and SO_2 concentration does not show most significant change. But concentrations of PM10 at site 1 have significant change it shows 2.5 times fold change in night time concentration as compared to the normal day. Results indicate SO_2, NO_x and PM10 levels inside homes are due to intrusion of pollutants from outdoor atmosphere also besides indoor air pollutants.

The short-term exposure of these pollutants and the high increase in their concentrations during Diwali festival can increase the likelihood of acute health effects. As Diwali is the festival of light and celebrated during night time, the unfavorable meteorological conditions (lower wind speed, lower boundary layer height etc.) for the dispersion of pollutants during night-time helps them to be accumulated near the earth surface till next day day-time. The same may be expected in other cities in India as this festival is celebrated all over the country. Hence, for the benefit of society, it is necessary to formulate proper strategy to control the emission and subsequent dispersion of the pollutants.

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