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RESEARCH ARTICLE

A STUDY ON AIR QUALITY STATUS DURING DIWALI FESTIVAL AT BHUJ CITY, KACHCHH DISTRICT, GUJARAT, WESTERN INDIA

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ABSTRACT

The present study was conducted in order to understand the impact of crackers and related fireworks usage during diwali festival (Festival of lights) in the ambient air quality status of Bhuj city during October 2014. This was assessed by evaluating the air quality status by measuring the concentrations of various air pollutants such as Sulphur Dioxide, Nitrogen Dioxide, Suspended Particulate Matter (SPM) and Respirable Suspended Particulate matter (RSPM) since usage of crackers is found to be the major activity during this particular festival and such firework related activity releases various gaseous and particulate air pollutants and toxic metals in a greater extent. Hence, in the present study, SO_2, NO_2, SPM and RSPM were estimated at selected residential sites during the day and night on diwali, Pre-Diwali and Post Diwali period. As a whole, it is understand that though the concentration of SO_2, NO_2, SPM and RSPM was found to be at a higher rate at pre and post diwali period, these specified parameters had recorded significantly higher levels of these concentrations on the day of diwali. On the day of Diwali, the levels of NO_2, SO_2, SPM and RSPM concentrations in residential area have been recorded as 65.86, 21.06, 311.8, 235 $\mu g/m^3$ respectively and the concentrations have also recorded higher range when compared with National Ambient Air Quality Standards (NAAQS). From the present study it is elucidated that the usage of fireworks and bursting crackers were found to be the major factors for such elevated levels of pollutants in the atmosphere during the Diwali festival.

INTRODUCTION

Diwali is one of the major festivals in India which is celebrated during the last quarter of the year mostly in the month of October / November. During this festival, huge amount of crackers and Fireworks are being used which in turn creates significant deterioration in the air quality status of most of the major and minor Indian cities. Since these crackers are made of many toxic chemicals which includes elements like manganese, aluminium, iron dust, potassium perchlorate, sulphur, coal, sulphur dioxide, heavy metals, barium nitrate, oxides of nitrate and other toxic chemicals into the atmosphere. Apart from this, other such toxic chemicals including, barium, rubidium, mercury, cadmium and bronze are also added to the fireworks in order to emit sparkling colors and inhaling the fumes or smoke of these chemicals may causes health complications in many folds when compared to regular non-festival days (Chauhan, *et al*., 2014). In India, many researchers have studied on such air quality status during diwali occasion and most of the studies infact have proved that during diwali occasion the air quality status is deteriorated to a significant extent wherein it is even reported that firework activities during Diwali has impacted on the surface Ozone in Delhi (Attri *et al*., 2001; Ganguly *et al*., 2009). Other than this, several researchers have found that usage of crackers and fireworks has lead to variation in air quality and observed increase in PM10 and TSPM concentrations in Hisar city and in Lucknow city during Diwali festival (Ravindra *et al., 2*003; Barman *et al.,* 2008, 2009). Another air quality assessment during diwali festival was conducted by Kulshrestha *et al.* in 2004 has reported high levels of various trace elements in the ambient air of Hyderabad city. Out of India, several studies have been conducted by researchers of other countries in order to understand the effect of crackers / firework on the air quality status in terms of particulate matter, gaseous pollutants (Bach *et al*., 1975). Drewnick *et al*. (2006) have studied the chemical composition and size distributions of fine aerosol particles during New Year's 2005 in Mainz, Central Germany. Vecchi *et al.* (2008) have observed elevated levels of some heavy metals due to firework activities during the celebration of FIFA world Cup in Italy in the year 2006. In a study conducted in California, following 4th July holiday reveals significant increase in the levels of aluminum, strontium,

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potassium lead, magnesium, barium and copper in the ambient air (Liu *et al*., 1997). Another detailed study during lantern day festival in Beijing on the air quality status revealed that extensive usage of fireworks reported 57.0, 25.0 and 183% increase in SO_2, NO_2 and PM_{10} levels when compared to the previous day. Besides these higher concentrations in the air, there is a strong relationship between higher concentration of SO_2 and several health effects like cardiovascular diseases (Chen *et al*., 2005b; Dockery *et al*., 2005). Keeping all the literature reviewed, the present study was planned in order to monitor air quality status by evaluating selected parameters such as SPM (Suspended particulate matter), RSPM (Respirable suspended particulate matter), Sulphur Dioxide (SO_2), Nitrogen Oxide (NO_2) in and around the residential area in Bhuj city, Kachchh district, Gujarat during the festival of lights in October 2014.

MATERIALS AND METHODS

Study Area

The study area Bhuj, the major town of Kachchh (Figure 1), is an old walled city in the past and it is has many old palaces with intricately carved wooden pavilions and decorated Hindu temples According to census 2011 population of the city is about 1,50,000. Bhuj resembles much of India before the tourist invasion. The present study area was selected in the residential area of the city ($23^0 15' 14.7" N$, $69^0 40' 07.4" E$).

Air Pollutants

The study was conducted in a residential area where there is good number of residents and the study was conducted during both day and night time. In order to understand the effect of crackers, 4 major air pollutants i.e., SPM, RSPM, SO_2, NO_2 were estimated in the selected location for a 24 hrs continuous ambient air quality monitoring. In the present study, ambient air quality was monitored using Envirotech's Respirable Dust Sampler was used for suspended particulate matter and for gaseous pollutants.

Estimation of Sulphur Dioxide (SO_2)

The concentration of sulphur dioxide in the collected samples were analyzed by modified (West and Gaeke., 1956) pararosaniline method in which air was passed through the impinger of high volume with a known quantity and the SO_2 in the ambient air was made absorbed in the solution of potassium tetrachloromercurate. A dichlorosulphitomercurate complex was formed, which was made to react with pararosaniline and formaldehyde to form intensely colored pararosaniline methylsulphonic acid and the resultant solutions absorbance of the solution was measured at wavelength of 560nm.

$$C(SO_2 \mu g/m^3) = (A_s - A_b) \times CF \times V_s / V_a \times V_t$$

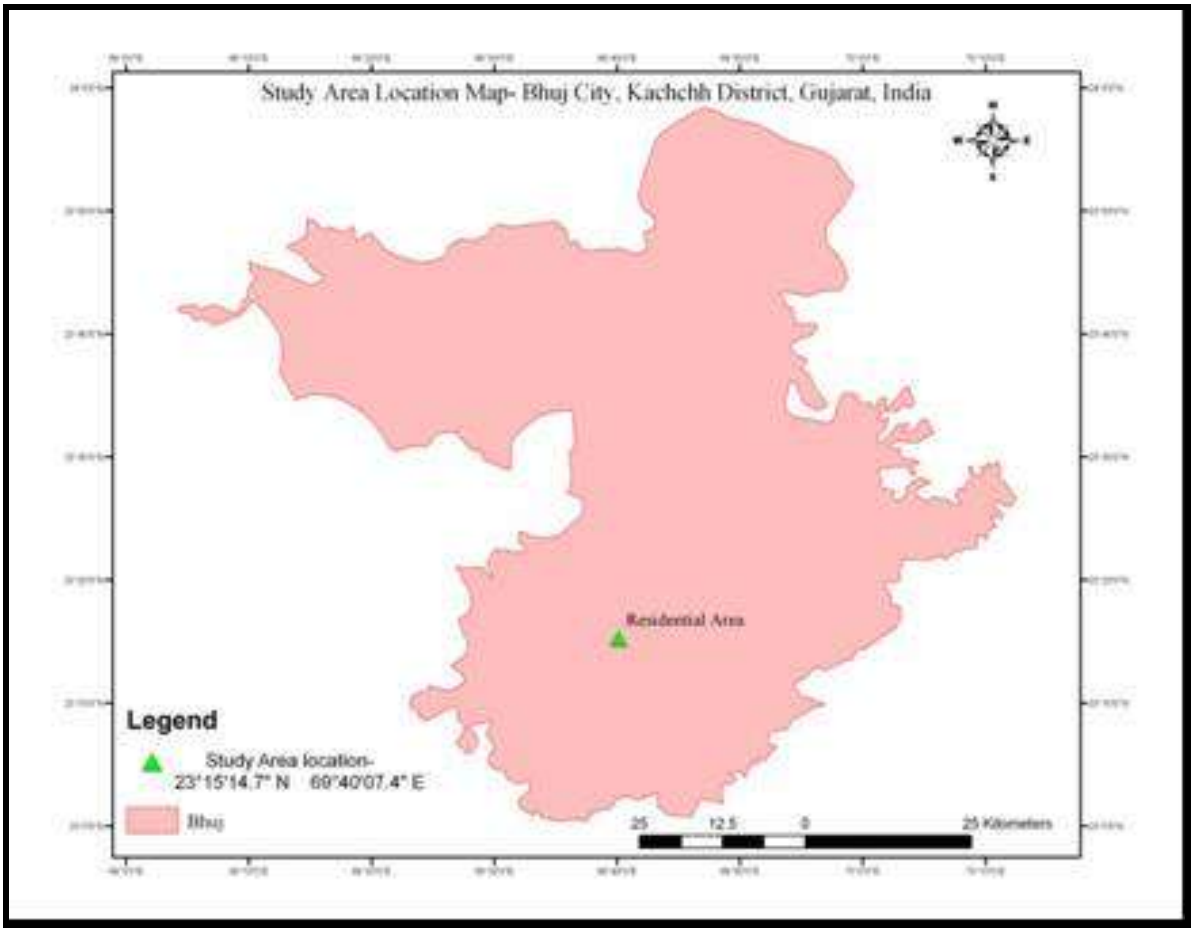

Figure 1. Map showing the study area

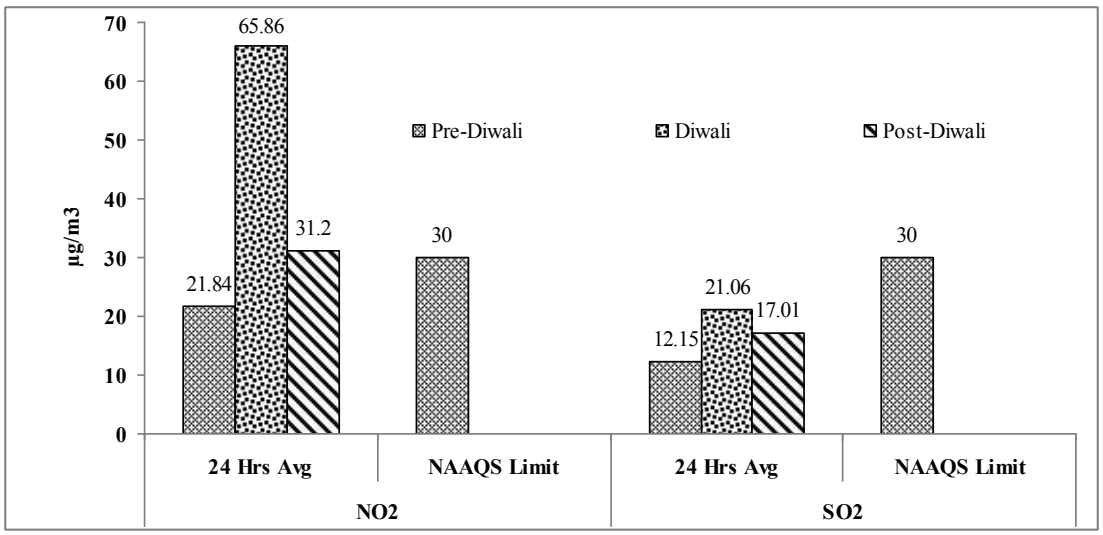

Figure 2. Graph showing the NO_2 and SO_2 concentrations recorded in the study area

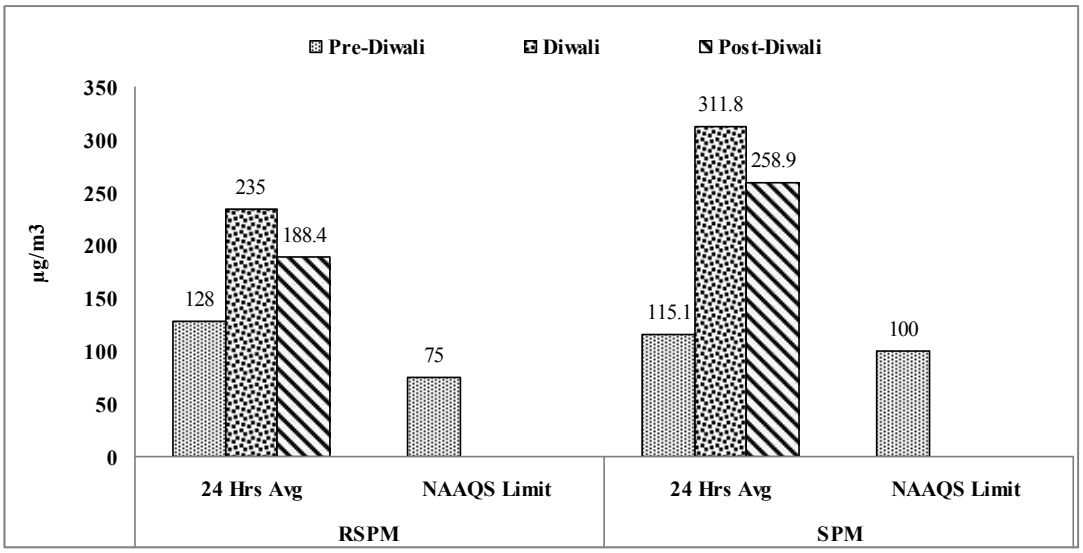

Figure 3. RSPM and SPM concentrations during the selected occasions in the study area

Where,

CSO_2 - Concentration of sulphur dioxide, µg/m^3
A_s - Absorbance of sample
A_b - Absorbance of reagent blank
CF - Calibration Factor
V_a - Volume of air sampled, m^3
V_s - Volume of Sample, ml
V_t - Volume of aliquot taken for analysis, ml

Estimation of Nitrogen Dioxide (NO_2)

NO_2 concentration in the ambient air was monitored by sodium Arsenite method (Jacobs and Hochheiser, 1958) by making NO_2 absorbed in the absorbing solution of sodium hydroxide and sodium arsenite to form a stable solution of sodium nitrite and was determined at a wavelength of 540nm and is calculated as per the formula given below.

$C(NO_2\ \mu g/m^3) = (A_s\text{-}A_b) \times CF \times V_s / V_a \times V_t \times 0.82$

Where,

CNO_2 - Concentration of Nitrogen dioxide, µg/m^3
A_s - Absorbance of sample
A_b - Absorbance of reagent blank
CF - Calibration Factor
V_a - Volume of air sampled, m^3
V_s - Volume of Sample, ml
V_t - Volume of aliquot taken for analysis, ml

Estimation of SPM and RSPM

The estimation of SPM and RSPM was done using glass micro filter paper GF/1 (20.3 X 25.4 cm) (8 x 10 inch) the ambient air and suspended particular matter was filtered and the RSPM in the air got deposited on the surface of filter paper. After sampling, filter paper was reweighed and amount of RSPM in the air for the sampling period was calculated.

$CPM_{10}\ \mu g/m^3 = (W_f\text{-}W_i) \times 10^6/v$

Where

CPM10 - Concentration of PM10, $\mu g/m^3$
W_f - Final weight of filter in g
W_i - Initial weight of filter in g
10_6 - Conversion of g to µg
V - Volume of air sampled, m^3

RESULTS AND DISCUSSION

The major pollutants responsible for various health effects were collected on diwali day and were compared with pre-diwali and post-diwali days and all the concentrations were compared with the prescribed limits as given by NAAQS and a detailed discussion on the same is given below.

Sulphur Dioxide (SO_2)

Sulphur-di-oxide is known to be toxic because of its nature of slowly getting absorbed in fine particles and are transported into the lung (Balram and Ghosh, 2013) and damages the tracheal nasal system (Bull *et al*., 2001). In the present study, the concentration of SO_2 on pre-diwali, diwali and post Diwali were estimated in the atmosphere is to be 12.15, 21.06, 17.01 $\mu g/m^3$ respectively. During Diwali day, the SO_2 concentration has increased up in the residential area and after Diwali, there was a slight decrease in the concentration of the same was observed whereas comparatively lowest concentration was recorded on Pre-Diwali day. Overall the collected data on SO_2 concentrations observed during the three day period showed that that the residential location has registered below level of SO2 as prescribed by NAAQS which is 30 $\mu g/m^3$ as showing in Figure 2. In a study conducted by Gong *et al*. (1995), where data on short-term health response to SO_2 exposure on asthmatic patients was done and the researchers found that exposure of SO_2 for 10 minutes period exposure at concentration > 1.32 mg/m^3 and ventilation 30 dm^3/ min can cause short term asthma problems in a significant manner than those usually get exposed without SO_2 exposure.

Nitrogen Dioxide (NO_2)

Similar to SO_2, most of the health effects exerted by NO_2 have impact in lungs which includes deep lung irritation, altered biochemical and histological phenomenon which was exhibited in laboratory animals (WHO, 1987). In the present study as shown in Figure 2, the concentration of NO_2 on Diwali and Post-Diwali day has been registered at elevated levels of 65.86 $\mu g/m^3$ and 31.2 $\mu g/m^3$ when compared with the NAAQ standards prescribed. Whereas, pre-diwali day has recorded a quite lower value of 21.84 $\mu g/m^3$ when compared to the other two days and also as per NAAQS prescribed concentration (30 $\mu g/m^3$). In a study conducted by Chauhan *et al*., (2014), high concentration of NO_2 of 52.69 $\mu g/m^3$ was registered during diwali festival in Jhansi city of Uttar Pradesh in the residential site whereas 60.26 $\mu g/m^3$ of NO_2 was recorded in the commercial location of the same town.

SPM and RSPM

Higher concentration of Particulate matter in air has more possibility of the particles to reach into the lungs and such particles caused severe health effects when entered into lungs since such particles carry mixture of pollutants present in the atmosphere derived from various sources including crackers and fireworks especially during diwali festival. Particles with diameter less than 10µm only can be respired to reach to the lungs and finer fractions less than 2.5µm such as fine particulate matter (FPM) can penetrate the lungs to alveolar level and can cause severe respiratory problems (Dominici *et al*., 2003; Pope *et al.,* 2006) including chronic respiratory and cardio vascular diseases, damage lung tissue and contribute to cancer (Dockery *et al*., 1993; Schwartz, 1993; Seaton *et al*., 1995; Bates, 1996; Levy *et al*., 2000; Pope *et al*., 2002; Steib *et al*., 2002, 2003; Dominici *et al*., 2003; Katsouyanni *et al.,* 2003; Pope *et al*., 2004; Torén *et al*., 2007). Figure 3 shows that the SPM levels in all the three days were found to be in a higher concentration of 115.1, 311.8, 258.9 $\mu g/m^3$ during Pre-diwali, Diwali and post-diwali days. Though the pre-diwali day recorded slightly higher concentration, diwali and post-diwali days registered 3 folds and 2 folds when compared to the standard levels prescribed by NAAQS which is 100 $\mu g/m^3$. Similarly, the trend of Respirable suspended particulate matter (RSPM) was observed where in the concentration increased up to 3 folds in the studied location where in diwali day recorded 235$\mu g/m^3$, 188.4 $\mu g/m^3$ on post diwali day (Figure 3). Lowest of 128 $\mu g/m^3$ was recorded on pre-diwali day among the three days and as per the comparison made with NAAQS which is 75$\mu g/m^3$.

Conclusion

To conclude, the present study provided a basic information of how the usage of crackers and fireworks has impacted on the air quality of a semi-arid town like Bhuj in terms of RSPM, SPM, SO_2 and NO_2, the four major parameters of air quality. Among the three days studied, most of the days recorded a slightly higher concentration of the pollutants except SO_2, whereas other pollutants were in a higher range as per the permissible limit of National ambient air quality standards (NAAQS). This study is important because release of such particulate matter and gaseous pollutants from crackers poses deleterious effects on human health especially during such festivals where huge amount of fireworks are being used.

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