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RESEARCH ARTICLE

GROUND LEVEL NO_2 TRENDS ON A DIURNAL SCALE OVER A METROPOLITAN COASTAL CITY, CHENNAI, INDIA

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ABSTRACT

Nitrogen oxides are major pollutants in the atmosphere, being a precursor to acid rain, photochemical smog, and ozone accumulation. Measurements of NO_2 and meteorological parameters (temperature, relative humidity, and wind speed) data over a period of two years (October 2014– September 2016) have been utilized to evaluate the NO_2 concentration levels over the area Ashok Pillar, Chennai. It is a steamy site which is situated at 13°08′N and 80°27′E on the southeast coast of India. The Diurnal, Seasonal and Annual pattern of NO_2 values over the study period has also been analyzed. The monthly variation of meteorological parameters shows little changes as it is being a coastal site. The changes in the No_2 level have been mostly influenced by the traffic intensity.

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INTRODUCTION

The air pollution and the acid rain have negative effects on the environment in which we live. The air pollution from transport includes emissions of carbon monoxide, particulates, nitrogen oxide and hydrocarbon. The oxides are mainly nitric oxide (NOx) and nitrogen dioxide (NO_2) both of which are corrosive and hazardous to health. With the use of catalytic converters on automobiles, the initial regulatory focus of controlling mobile NOx emissions has reached the point where further restriction has become economically impractical. The importance of the NO_2 is based on its key role in the atmospheric chemistry. As found by Crutzen in 1970 (Crutzen, 1970) and Johnston in 1971 (Johnston, 1971), active nitric oxides NOx = ($NO+NO_2$) destroy the ozone catalytically. Nitrogen dioxide is toxic to the biosphere species. It converts into nitric acid (HNO3) and contributes to acid rain, which is harmful to the entire (terrestrial + aquatic) ecosystem (Gauss *et al.*, 2007). NO_2 is a very imprudent and act as a major catalyst in the troposphere ozone production. NO_2 is an important atmospheric compound because of its link to ozone destruction in the stratosphere and its role as an ozone precursor in the troposphere (Dufour, 2006). In recent years, NO_2 pollution has become a cause of increasing concern because emissions of NOx are steadily increasing, especially in urban areas, despite the growing appreciation by public utilities for reducing NO_2 emissions. Road traffic has been identified as a major contributor to the deterioration of air quality in urban areas (Mage *et al.*, 1996) (Mayer, 1999). More specifically, motor vehicles substantially contribute to urban levels of nitrogen oxides through their engine combustion processes (Emberson *et al.*, 2003). Through this study, ground level NO_2 and Meteorological parameters (temperature, relative humidity and wind speed) were measured for period of two years from October 2014 to September 2016 during the four seasons (North-East Monsoon, Winter, Summer and Pre-Monsoon). In this study, ground level NO_2 concentrations were measured at area around Ashok pillar Chennai. Chennai is a metropolitan city which is on the Bay of Bengal in Eastern India. Ashok Nagar is a residential locality situated at the southern part of Chennai, India. At the heart of this colony, stands the Ashok Pillar. This is the suburban locality, and the Tamil Nadu Housing Board constructed flats during the 1970s for middle-income group, covering an area of 7 sq km including the neighborhood of K. K. Nagar. The consequence of this current

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study is to offer an imminent into the level of NO_2 concentration at the study area and also to understand the behavior of NO_2 in the different seasons.

Experimental

Measurement Site and Methodology

Chennai is one of the four major metropolitan cities, located on the south east coast of India. The city is 25.6 km in length and extends inland to about 11 Km and the total area is 174 Km2. The geographical coordinates of the study area are 13°10′04″N latitude and 80°15′43″ E longitude and it is located at an average altitude of 6.7 meters from the sea level (Jayanthi and Krishnamoorthy, 2006). The study area is Ashok pillar, which is most important entry-exit point of Chennai. This study area is of importance mainly because this region is now slowly developing into a well known area with new infra-structural developments as Chennai Metro Railway station introduced by the Government. It is located nearby Koyambedu, a hub for Chennai's Mofussil buses, this terminus has a capacity to handle over 2,00,000 passengers a day, hence vehicular emission is very high. The study area receives heavy rainfall only during north-east monsoon (October-December). The month of January is the representative of the winter season (January-February). The climate at the measurement site during May is the representative for summer season (March-May). The climate at the study site during May is very hot due to intense solar radiation. The month of July is the representative of the pre-monsoon season (June-September). Partly cloudy sky and hot weather with no rain characterizes the pre-monsoon season (Debaje *et al*., 2010).

Data Collection

The measurement of NO_2 in parts per billion (ppb) was carried out using an Aeroqual Series 500 Handheld Monitor (Aeroqual Limited, New Zealand) at the area around Ashok Pillar, Chennai. Gas Sensitive Semiconductor (GSS) technology is next up the stepladder for exact measurement of NO_2 at lesser level. The sensor can detect NO_2 values in the range of 0.0-0.200 ppm with a resolution of 0.001 ppm. The annual and seasonal diurnal means of NO_2 are computed by averaging all months of a year. NO_2 concentrations and meterological parameters were measured at the study area for a period of two years from October 2014 to September 2016. This study period covers all the four different seasons experienced by the study area. The Meteorological data was collected from Indian Meteorological Department (IMD) and Tamilnadu Pollution Control Board (TNPCB), Chennai.

RESULTS AND DISCUSSION

Diurnal Variation of NO_2

During the entire study period, the NO_2 concentration varied from 5 ppb to 45 ppb. The diurnal cycle of NO_2 showed an entire pattern and was characterized by the minimum NO_2 concentration in afternoon hours and maximum NO_2 concentration in the midnight and morning hours. It is seen from figure 1 that highest NO_2 concentration 28.43 ppb was observed at around midnight 01:00 am and minimum of NO_2 concentration 15.56 ppb was observed in the afternoon at 15:00 pm .It is noted that the small upper side kink in the diurnal pattern of NO_2 were observed at around 11:00 am. On a daily cycle, as industrial and motor vehicle activity rises in the morning hours, concentrations of NOx and VOCs also rises. The morning high values of NO_2 concentration in the study area is mainly due to the increase in traffic flow. This is associated with weak winds, besides atmospheric stability which is the characteristic of the 'nocturnal stable boundary layer' that persists in the first hours of the morning (Teixeira *et al*., 2009). After sunset, the photochemical reaction stops and so there is decrease in Ozone concentration, hence NO_2 concentration increases in the complex nighttime chemistry of the atmosphere.

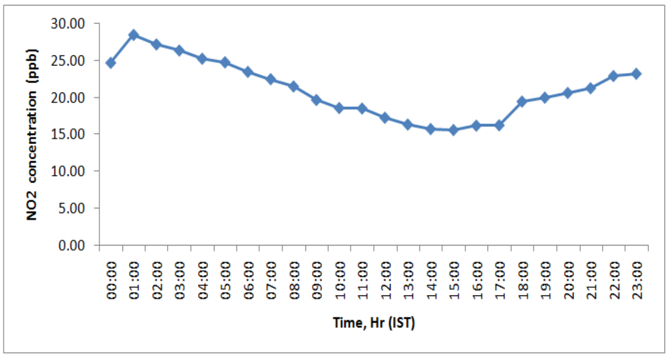

Fig.1. Diurnal Variation of NO_2 Concentration

Seasonal Diurnal Variation of NO_2

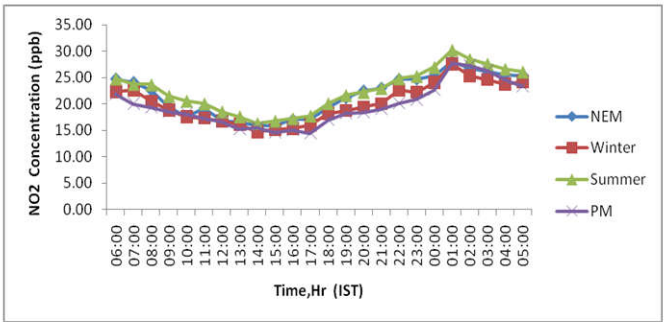

Fig.2. Seasonal Average Variation of Ground level NO_2

The seasonal average values of NO_2 concentration from October 2014 to September 2016 can be implicit from the Figure 2. A proper seasonal variation of NO_2 concentration was observed in the study area. Though the maximum ground level NO_2 was observed in winter it was minimum in monsoon months in the study regions. For two years, winter season recorded the maximum concentration of NO_2. The maximum observation found in winter is due to the local thermal activities and population density (Kalita and Bhuyan 2011).

Seasonal average of daytime, nighttime and Daily values of NO_2

The yearly averages of day, night and daily values are depicted in Figure 3. It is observed that for all the two years, the night time values are quite higher as compared to the daytime values. The year 2015- 2016 records higher day and night values in comparison to 2014-2015 values. This increase in nighttime is bound to occur due to the non-existence of photochemical reaction and subsequent decrease in the ozone levels during the night hours.

Fig.3. Annual average Daytime, nighttime and Daily values of NO_2

Relationship with Climatologic Variables and NO_2

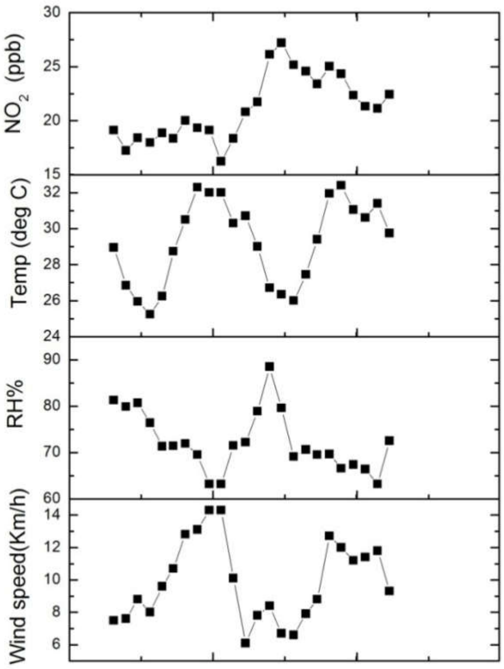

Fig.4. Influence of meteorological parameters on NO_2

The monthly mean NO_2 concentrations were related to temperature, relative humidity and wind speed. Figure 4 represent the relationship between the NO_2 concentration and these climatic variables. Figure 4 suggests that the NO_2 concentration level might be positively related to the relative humidity (in percent) and negatively related to temperature (measured in degree Celsius). Periods with lower temperatures and higher humidity usually correspond with higher values of NO2. Thus, in the months of November'15, December 15'and January 16', concentration values of NO2 were higher, and this fact could be due to the high humidity and low temperature of those months. This has already been described in literature (Chan *et al*., 2001) (Lieu *et al*., 1987). This can again be attributed to the fact as indicated above that during winter as a result of reduced solar radiation, NOx are not photolysis and tends to accumulate. The figure 4 clearly depicts the fact that periods with higher wind speed is usually correspond with lower values of NO_2. Thus, in PM season, i.e. from March (15 and 16) to June (15 and 16) as the rate of wind speed increased, the concentration of NO_2 gradually decreased. This can be attributed to the fact that with increased wind speed, dispersion and transportation of pollutants take place.

Conclusion

The diurnal pattern of NO_2 in the study area is found to be in concurrence with the global diurnal pattern of NO_2. The seasonal diurnal pattern of NO_2 shows a high value during the summer as compared to the rest of the seasons. The daytime values of NO_2 is found to be low as compared to its night time values and this shows that NO_2 clearly compliments the ozone levels in the surface level. The analysis confirms that NO_2 positively correlated with relative humidity and negatively correlated with wind speed and temperature. The Annual maximum level observed in 2015-16 is 23.21 ppb and is minimum of 19.64 ppb in 2014-15.

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