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Characteristic Behaviour of NO_2 Pollutant Over a Rural Coastal Area Along the Bay of Bengal

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ABSTRACT

Analysis of the characteristic behaviour of NO_2 is quite essential because of its link to ozone destruction in the stratosphere and due to its role as an ozone precursor in the troposphere. Two-year long continuous (October 2013-September 2015) NO_2 data have been utilized to assess the NO_2 pattern over Karaikal, a rural coastal region along the south eastern coast of India. The frequency distribution of NO_2 shows that about 80% of the total 17520 data points of NO_2 lie between 5 ppb to 20 ppb. The highest distribution is found in the range of 10-15 ppb while the lowest lies in the 25-30 ppb. The measured NO_2 levels have been examined on a diurnal and seasonal scale. The diurnal scale of NO_2 shows high values during the night hours and lesser values in the daytime. It is clear that NO_2 concentrations are high during summer and minimum during the north-east monsoon. The daytime and nighttime NO_2 concentration pattern is found to be comparable with the global scenario. It is observed that for all the two years, nighttime values are much greater than the daytime values. It is observed that the NO_2 concentrations in the study area are not high enough to pose health problems. The NO_2 concentration levels are well within the national standards in the study area for the entire period of study.

INTRODUCTION

Nitrogen oxides are found to be very vital chemical species in the atmospheric boundary layer as well as in the free troposphere and the stratosphere. In total there are about seven oxides of nitrogen in the ambient atmosphere. Of these seven oxides, the most important forms of reactive nitrogen in the air are in the form of nitrogen monoxide (NO) and nitrogen dioxide (NO_2). NO_2 plays a major part in the control of concentrations of radicals in the troposphere, in the production of tropospheric ozone, as an aerosol precursor and in the production and deposition of acidic species directly or indirectly (Logan 1983). The interconvertibility of NO and NO_2 in photochemical reactions has often resulted in their being grouped under the designation of NOx (Crutzen 1995).

Due to an increase in the anthropogenic sources like transportation, stationary fuel combustion, various industrial processes, solid waste disposal, the NO_2 emission levels have also found to have a corresponding rise. NO_2 is involved in catalytic cycles of ozone destruction and it also takes part in the process of conversion of reactive chlorine, mainly in the lower stratosphere (Werner et al. 2006). The relationship of NO_2 to ozone formation and destruction has enhanced the necessity for climate modeling and for related atmospheric studies.

The work reported in this paper provides an investigation to reveal the characteristic behaviour of ground level NO_2 at the observation location. Karaikal (10.9327 °N, 79.8319 °E), the chosen study area for this work is situated in the south-eastern coast of India. This study area has an importance, mainly because this region is now slowly developing into a well known city with new port and other new infra-structural developments introduced by the Government. This region attracts lot of tourists as it has many pilgrimage spots around it and is one of the temple town area's of Tamilnadu.

The climate at the measurement site during May is the representative month for summer season (March-May). The climate at the study site during May is very hot due to intense solar radiation. The daytime temperature always remains above 35°C and nighttime temperature also hovers around 30°C. 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 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. 2003).

MATERIALS AND METHODS

NO_2 levels were continuously monitored every hour from October 2013 to September 2015 using the Aeroqual S500 gas sensitive sensor, which is based on the gas sensitive semiconductor technology (GSS Technology). The GSS technology is a combination of smart measurement techniques

and mixed metal oxide semiconductor sensors that exhibit an electrical resistance change in the presence of a target gas. This particular instrument was chosen for its simplicity in operation, quickness in obtaining the gas concentration and most important the fully interchangeable sensor heads which eliminate the need for field calibration. The unit of measurement is either ppm or $\mu g/m^3$. NO_2 sensor was calibrated against a certified chemiluminescence NO_2 analyser.

RESULTS AND DISCUSSION

The data obtained for 24 months from October 2013 to September 2015 were analyzed on the basis of diurnal and seasonal variations. The daily readings were averaged to obtain the daily average and readings from 06.00 hrs to 18.00 hrs were averaged to obtain daytime NO_2 concentration and the mean of the concentrations at 19.00 hrs to 05.00 hrs gives the nighttime average NO_2 concentration.

Frequency distribution of NO_2 concentration: The frequency distribution of NO_2 in different concentration range is as shown in Fig. 1. It is noticed that about 80% of the total 17520 data points of NO_2 lie between 5 ppb to 20 ppb. The highest distribution is found in the range of 10-15 ppb, while the lowest lies in the 25-30 ppb.

Diurnal variation of NO_2: Diurnal cycles of nitrogen oxides can be caused by photochemical transport and emission processes and their strengths do vary depending on the time of the day. Fig. 2 shows the average diurnal variation of NO_2 in Karaikal during 2013-2015.

The diurnal scale of NO_2 shows high values during the night hours and lesser values in the daytime. The high values observed till 08.00 hrs are due to the increase in traffic flow and the associated weak winds besides atmospheric stability which is the characteristic of the nocturnal stable boundary layer that is found to persist in the first hours of the morning (Teixeira et al. 2009). The decrease in NO_2 in the late morning hours from 9.00 hrs coincides with the appearance of ozone in the atmosphere. Ozone now accumulates and reaches a maximum in the afternoon hours and then gradually declines during the following several hours. The concentration of NO_2 usually declines from its peak as the ozone builds up and NO_2 concentration reaches its minimum level in the afternoon. After sunset, the photochemi-

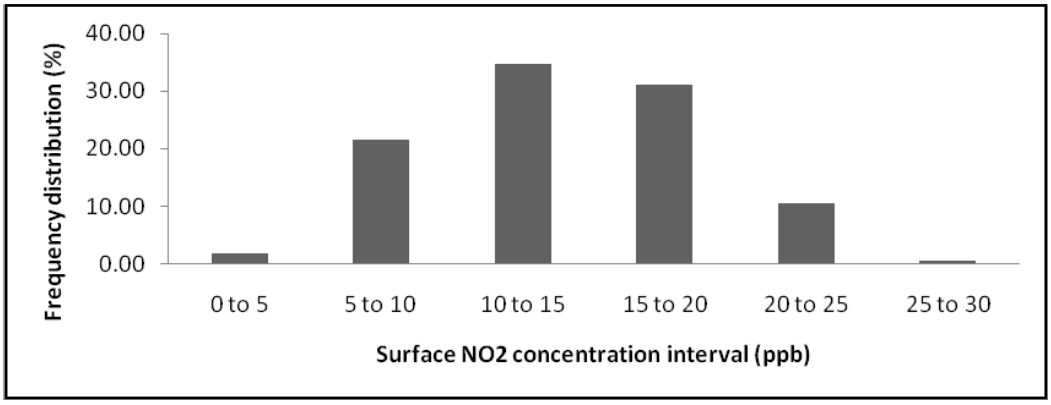

Fig. 1: Frequency distribution of NO_2 measurements (October 2013-September 2015).

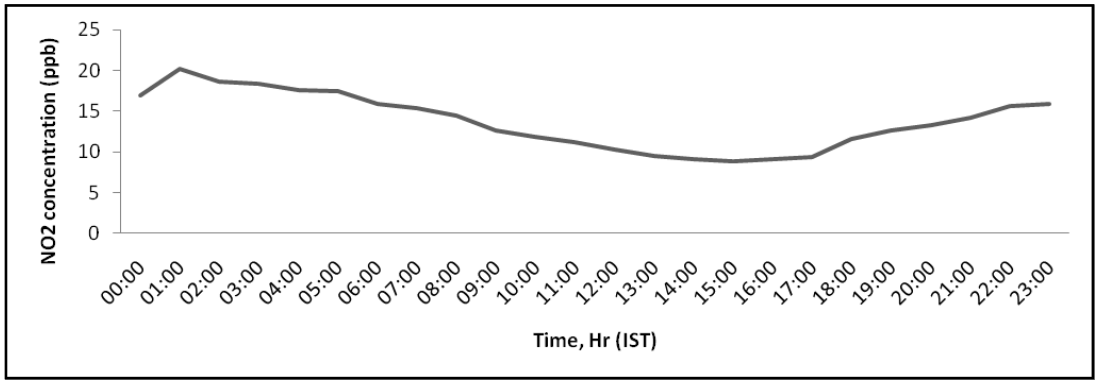

Fig. 2: Diurnal variation of NO_2 at Karaikal (2013-2015).

cal reaction terminates and hence ozone concentration decreases while NO_2 increases due to the complex nighttime chemistry of the atmosphere. Another factor that influences the NO_2 concentration is the height of the mixing layer. On a clear day, pollutants would be diluted when the mixing layer rises during the daytime and is limited to inside the nocturnal planetary boundary layer (NPBL) during the nighttime. The comparative diurnal variation for different seasons (Fig. 3) shows reasonable consistency with low NO_2 concentration levels during the daytime and high values for the nighttime.

Seasonal average of daytime, nighttime and daily values of NO_2: The yearly averages of day, night and daily values of NO_2 concentrations are as shown in Fig. 4. It is observed that for all the two years, nighttime values are much greater than the daytime values. The period 2013-2014 records lowest daytime and nighttime values as compared to those of 2014-2015. This may be attributed to the increased anthropogenic activities.

Seasonal average of monthly values of NO_2: The seasonal averages of monthly values of NO_2 are depicted in Fig. 5. All the seasons have found to exhibit similar pattern for the entire period of observation. It is clear that NO_2 concentrations are high during summer and low during the north-east monsoon. Comparing the two years, a slight increase in the concentration of NO_2 is observed for all the seasons between 2013-2015. From this particular result, it is inferred that there is no incident of abnormal production of NO_2 in any season in the study period and hence the moderate NO_2 emission becomes the characteristic of the study area.

CONCLUSION

A continuous two-year NO_2 measurement in the study area has been analyzed on a diurnal and seasonal scale. The frequency distribution of NO_2 concentration reveals about 80% of the values lie in the range of 5-20 ppb. The highest distribution is found in the range of 10-15 ppb while the lowest lies in the 25-30 ppb. The highest NO_2 concentration is found in summer, while the lowest in the north-east monsoon. On a diurnal scale, NO_2 levels show an increase

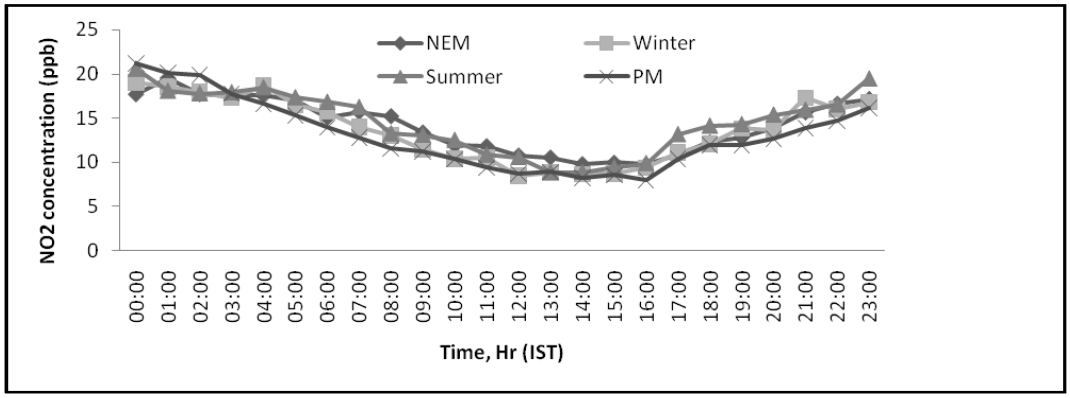

Fig. 3: Average seasonal diurnal variation at Karaikal (2013-2015).

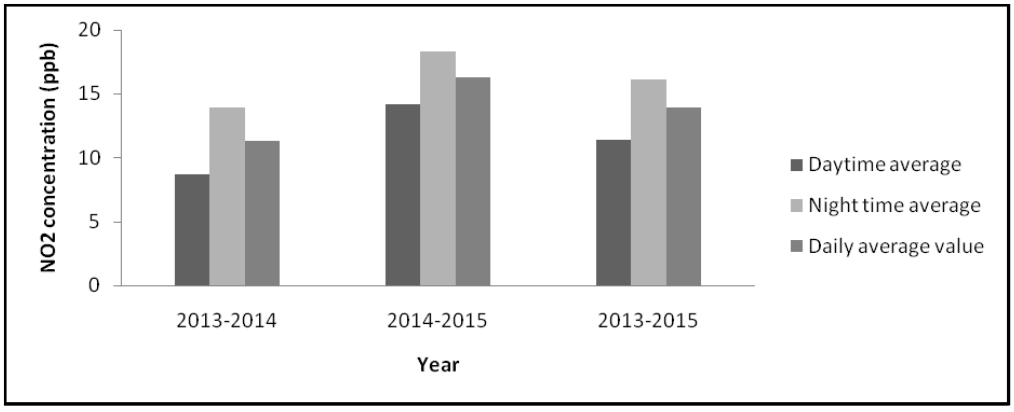

Fig. 4: Daytime, nighttime and daily average NO_2 values at Karaikal (2013-2015).

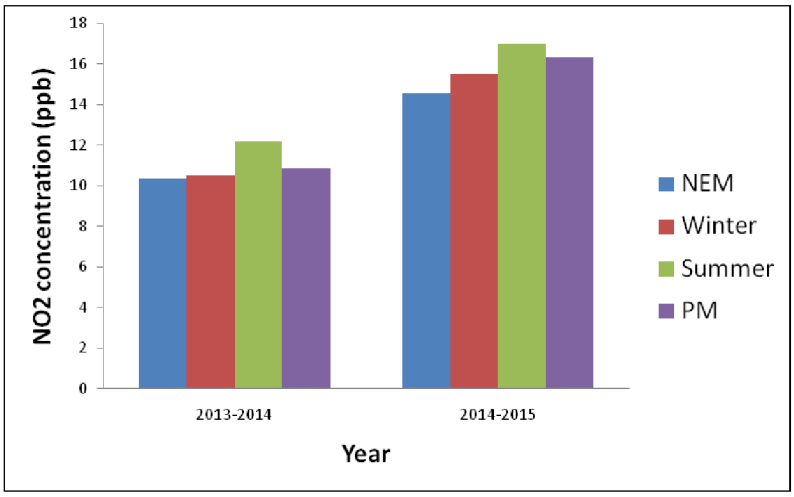

Fig. 5: Seasonal average of monthly values of NO_2.

during the night hours and are found to lower during the day hours, which is found to be in concurrence with the ozone production and destruction. The NO_2 concentrations in the study area are not high enough to pose health problems. It is found that the NO_2 concentration levels are well within the national standards.

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