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RESEARCH ARTICLE

ASSESSMENT OF NO_2 OVER A RURAL COASTAL REGION ON A DIURNAL SCALE

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ABSTRACT

Nitrogen dioxide (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. Availability of NO_2 data over a period of one year (October 2013 – September 2014) has been utilized to assess the NO_2 concentration levels over Karaikal, a rural coastal region along the south eastern coast of India. The diurnal and seasonal pattern of NO_2 values over the study period has also been analyzed. The daytime and nighttime NO_2 concentration pattern is found to follow the global pattern.

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INTRODUCTION

Nitrogen oxides are important chemical species in the free troposphere and the stratosphere. Of the seven nitrogen oxides, the most important forms of reactive nitrogen in the air are nitrogen monoxide (NO) and nitrogen dioxide (NO_2). NO_2 is a very reactive and significant species in the atmosphere. It plays an important role in the control of concentration 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). Antropogenic sources of NO_2 emissions include transportation, stationary fuel combustion, various industrial processes, solid waste disposal and others such as forest fires. Natural sources are lightning, biological and abiological processes in soil and stratospheric intrusion. 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 the troposphere, environmental impacts of NO_2 are mainly due to its deposition and its role in ozone formation. Since the pre-industrial times, tropospheric NO_2 has increased six times, being highest in large urban areas and at the same time ozone has been doubled in the Northern hemisphere (Werner *et al*., 2006).

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The relation of NO_2 to the ozone production and ozone destruction enhances its importance for climate model and atmospheric studies. Hence, monitoring NO_2 has become an important step towards the characterization of any environment.

During this study, surface level NO_2 were measured every hour for period of one year from October 2013 to September 2014 which covers all the four seasons (Summer, Pre-Monsoon, North-East Monsoon and Winter). In this study, surface level NO_2 concentrations were measured at Karaikal, a coastal region along the south eastern India. This study area attracts numerous tourists as there are numerous pilgrimage spots around this area. A newly developed port and chemical industries are also located around this area. The importance of this present study is to provide an insight into the level of NO_2 concentration at the study area and also to understand the behavior of NO_2 in the different seasons. This is a very crucial in understanding the atmospheric concentrations and their lifetimes and the environmental impacts that can be expected with modifications to their sources and sinks.

Measurement Site and Methodology

Karaikal (10.9327 N, 79.8319 E), is situated along the south eastern coast of India (Figure 1). This study area is of 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 lots of tourists as it has many pilgrimage spots around it. 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 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*., 2010). Aeroqual S500 gas sensitive sensor was utilized to measure ozone concentrations in the study area. Technology is next up the ladder for accurate measurement of NO_2 at lower level. Maintenance issues and the need for calibration are also eliminated with this technique. Sensing heads can be removed and new ones inserted in the field.

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.GSS technology is the culmination of more than 25 years of material research perfecting material formulations and optimizing sensor driver algorithms. These GSS sensor-based monitors have been designed to provide near scientific accuracy, high reliability and functionality at an affordable price. The working of Aeroqual S500 (Figure 2) is based on this GSS technology technique. The sensor can detect NO_2 values in the range of 0.0-0.200 ppm with a resolution of 0.001 ppm. The NO_2 concentrations were measured continuously for 24 hours a day at the study area for a period of one year from October 2013 to September 2014. This study period covers all the four different seasons experienced by the study area.

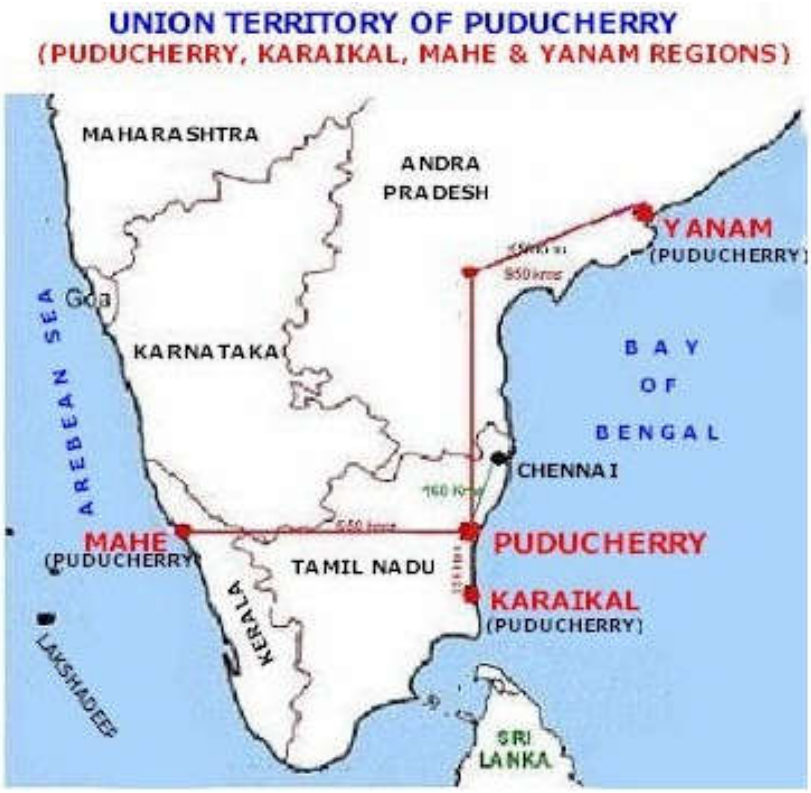

Figure 1. Study area

Figure 2. Aeroqual S500 Gas sensitive sensor

RESULTS AND DISCUSSION

Diurnal Variation of NO_2

24 hours surface level NO_2 concentration averages measured from October 2013 to September 2014 are presented in Figure 3. This diurnal cycle of NO_2 is as a result of the photochemical, transport and emission processes and their strengths vary between day and night.

The morning high values of NO_2 concentration in the study area is mainly due to the increase in traffic flow. This is also associated with weak winds besides atmospheric stability which is the characteristic of the 'nocturnal stable boundary layer', that still persists in the first hours of the morning (Teixeria *et al*., 2009). The decrease in NO_2 in the late morning hours (from 8.00 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

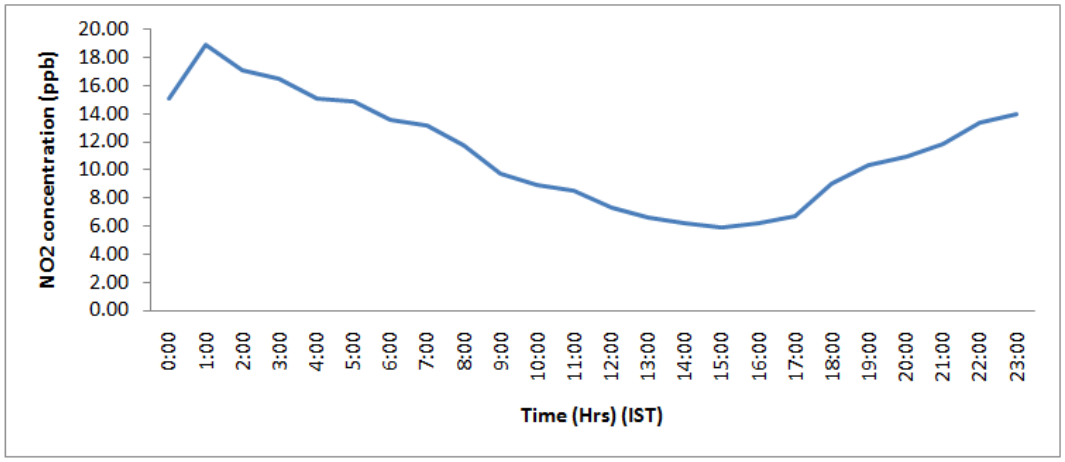

Figure 3. Diurnal Variation of NO_2 Concentration

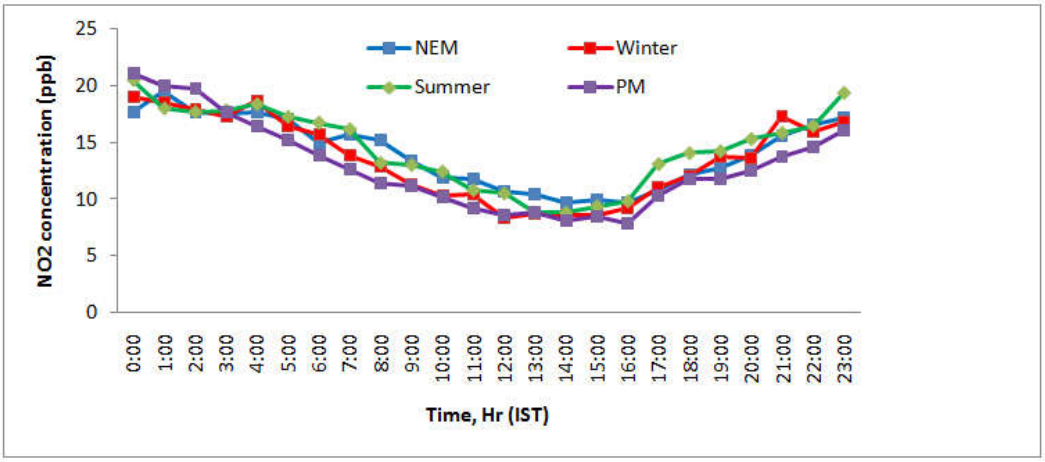

Figure 4. Seasonal Diurnal Variation of NO_2 Concentration

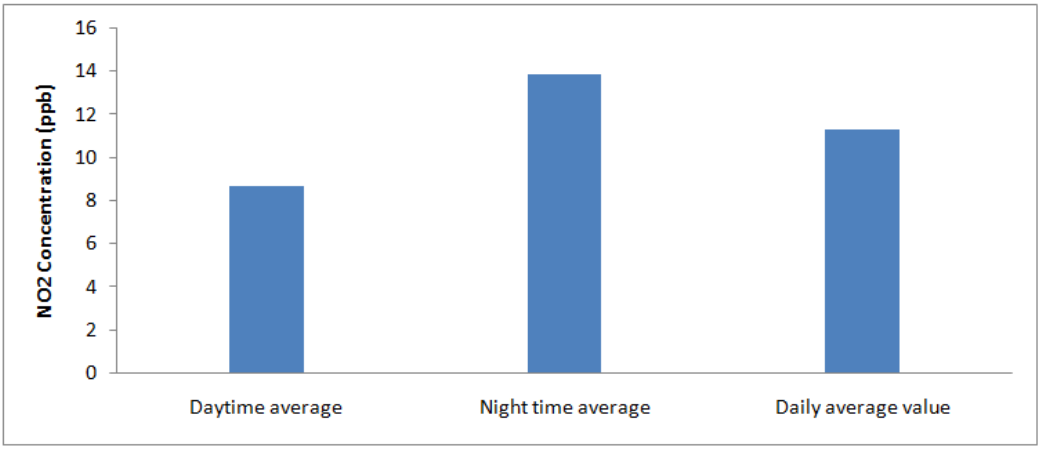

Figure 5. Daytime, Nighttime and Daily average values

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, at which the production of ozone is maximum. Eventually, after sunset, the photochemical reaction stops and hence ozone concentration decreases while NO_2 concentration increases in the complex nighttime chemistry of the atmosphere.

Seasonal Diurnal Variation of NO_2

The seasonal average values of NO_2 concentrations from October 2013 to September 2014 can be understood from Figure 4. Daily average value of the summer is observed to be the highest. The daytime lower values of NO_2 are the result of photochemical production of ozone in highly conducive summer weather. The higher values of NO_2 at nighttime are due to the dominating ozone destruction processes in the atmospheric chemistry. During nighttime the ozone molecule reacts with NO to give NO_2 and hence a higher concentration of NO_2 is observed. From Figure 4, it is observed that the diurnal pattern of NO_2 for North East Monsoon (NEM) follows almost the same pattern of summer variation but with a different range of values. The lowest values around afternoon may be due to exactly opposite physical and chemical factors prevailing over the location of observation. Heavy rainfall, thick cloud coverage, lower solar flux density and hence lower temperature, high relative humidity lead to the lower values of NO_2. The Winter and Pre-Monsoon (PM) values lie in between summer and NEM seasons.

Daytime, Nigttime and Daily values of NO_2

The daytime, nighttime and daily average values of NO_2 is as shown in Figure 5. The Figure 5 shows a clear high concentration of NO_2 during the nighttime hours as compared to the values during the daytime. 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.

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 nighttime concentration of NO_2 is found to be high as compared to its daytime values and this shows that NO_2 clearly compliments the ozone levels in the surface level.

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