Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
e-ISSN: 2395-3454

Vol. 18 | No. 3 | pp. 1073-1076 | 2019

Original Research Paper | Open Access

Characteristic Behaviour of the Air Pollutant NO_2 Over an Urban Coastal Area Along the Bay of Bengal

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 19-02-2019
Accepted: 29-03-2019

Key Words:
Air pollution
Nitrogen dioxide
Diurnal and seasonal scale
Urban coastal area

ABSTRACT

To study the characteristic behaviour of NO_2 is quite necessary. Nitrogen dioxide is a major pollutant in the atmosphere, being a precursor to acid rain, photochemical smog, and ozone accumulation. Measurements of NO_2 data over a period of one year (October 2014-September 2015) have been used to evaluate the NO_2 concentration levels. The frequency distribution of NO_2 reveals that out of the total 8760 data points, about 86% of NO_2 lies between 5 ppb and 20 ppb. The lowest distribution is found in the range of 0-5 ppb, while the highest lies in the range of 10-15 ppb. The NO_2 measurement level has been examined on a diurnal and seasonal scale. The diurnal scale of NO_2 shows lesser values during daytime and higher values during night hours. The NO_2 concentration levels are high in summer and minimum in the north-east monsoon. The daytime and night-time NO_2 concentration pattern is found to be similar to the global scenario. It is observed that the NO_2 concentrations in the study area are not high enough to pose health problems. The observed NO_2 concentration levels at the study area are well within the National Ambient Air Quality standard for the entire period of study.

INTRODUCTION

The air pollution and 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 hydrocarbons. One large group of urban air pollutants of major concern are photochemical oxidants. Amongst the most important ones is NO_2, which has adverse impacts on human health and the environment (World Health Organization 2000). Road traffic has been identified as a major contributor to the deterioration of air quality in metropolitan 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). 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 emission. NO_2 is brought into the environment by normal causes, including access from the stratosphere, bacterial respiration, volcanoes, and lightning. These made NO_2 as a trace gas in the Earth atmosphere, where it plays an important role in absorbing sunlight and regulating the tropospheric chemistry, especially in determining the ozone concentrations. NO_2 plays the main 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).

In the stratosphere, NO_2 is intricate in the catalytic cycles of ozone destruction, and it also takes part in the methods of conversion of reactive chlorine in its reservoir form, mainly in the lower stratosphere. Lower in the atmosphere at the tropospheric level, the environmental impacts of NO_2 are mainly due to its deposition and as a result of its role in ozone formation. The relationship of NO_2 to ozone creation and destruction has enriched the necessity for climate modelling and atmospheric related studies.

The study area chosen for this work is situated at Ashok Pillar Chennai. Chennai city is the capital of Tamil Nadu state in south India and is located on the eastern coast. The latitude and longitude of the centre of the city are 80°14'51" E and 13°03'40" N. Chennai has tropical wet and dry climatic conditions. The minimum temperature recorded is 19°C with maximum temperature of 42°C. The annual average rainfall in Chennai is about 1400 mm. The study area Ashok Pillar is the most important entry-exit point of Chennai. This 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, and hence vehicular emissions are very high.

The study area receives heavy rainfall only during north-east monsoon (October-December). The January month is representative of the winter season (January-February). The climate at the study site during May is the representative for summer season (March-May). The month of May is very hot due to intense solar radiation. July month 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). The consequence of the current study is to offer an imminent level of NO_2 concentration and also to understand the behaviour of NO_2 at the study area.

MATERIALS AND METHODS

The NO_2 concentrations at the study area were continuously observed every hour from October 2014 to September 2015 using an Aeroqual Series 500 gas sensitive sensor. It is based on the gas sensitive semiconductor technology (GSS Technology). The GSS technology is next up the stepladder for exact measurement of NO_2 concentration at lesser level. This sensor can detect NO_2 values in the range of 0.0 to 200 ppm with a resolution of 0.001 ppm. The unit of measurement is either µg/m^3 or ppm. NO_2 sensor was calibrated against a certified chemiluminescence NO_2 analyser.

RESULTS AND DISCUSSION

The observed NO_2 data were analysed on the basis of diurnal and seasonal variations. All hourly values were used to analyse diurnal variability and the daily averaged values used to analyse day-to-day variability. The readings from 19.00 hrs to 05.00 hrs and 06.00 hrs to 18.00 hrs were averaged to obtain the night-time and daytime NO_2 concentrations respectively. Monthly averages are calculated from the daily values, to study the seasonal cycle.

Frequency distribution: The frequency distribution of NO_2 in different concentration range is shown in Fig. 1. It is noticed that about 86% of the total 8760 data points of NO_2 lie between 5 ppb and 20 ppb. The lowest distribution is

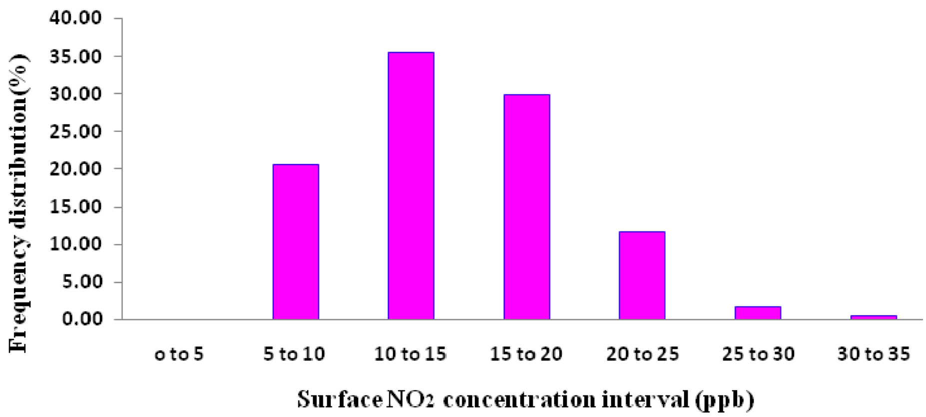

Fig. 1: Frequency distribution of NO_2 measurements at the study area during the period (October 2014-September 2015).

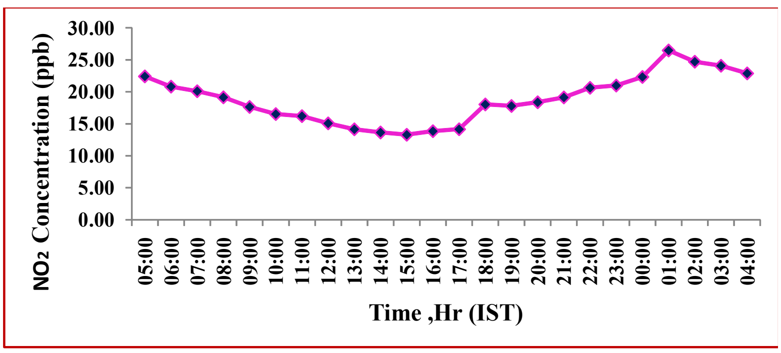

Fig. 2: Diurnal variation of NO_2 during the study period (October 2014-September 2015).

found in the range of 0-5 ppb, while the highest lies in the 10-15 ppb.

Diurnal variation of NO_2: Diurnal cycles of nitrogen oxides are usually caused by photochemical transport and emission processes and their strength is found to fluctuate between daytime and night-time. The overall diurnal variation of NO_2 for the study period October 2014-September 2015 at Ashok Pillar, Chennai is shown in Fig. 2.

During the study period, the NO_2 concentration varied from 5 ppb to 35 ppb. The diurnal cycle of NO_2 shows minimum values in afternoon hours and maximum values in the night hours. It is seen from Fig. 2 that the highest NO_2 concentration 26.45 ppb was observed at around midnight 01:00 a.m, and minimum NO_2 concentration of 13.30 ppb in the afternoon hours at 15:00 p.m.

In general, there is a rise of NO_2 concentration in the early morning hours at the study area due to increase in traffic flow, weak winds besides the atmospheric stability, which is the characteristics of the "nocturnal stable boundary layer". This layer is found to persist till the first few hours of the morning (Teixeira et al. 2009). After 09:00 a.m., increase in downward solar flux initiates a series of photochemical reactions between several precursors resulting in formation of O_3 by the conversion of NO_2 to NO. Hence, low NO_2 concentrations are noted during afternoon hours. After 15:00 p.m., NO_2 concentration gradually increases and reaches to a peak value at midnight. Because, after sunset, the photochemical reactions stop, and hence ozone concentration decreases while NO_2 concentration increases in the complex night-time chemistry of the atmosphere. One more important factor that influences the NO_2 concentration level is the height of the mixed layer above the observation site. On a clear day, pollutants would be diluted when mixing layer rises during the daytime and is restricted to inside the nocturnal planetary boundary layer (NPBL) during the night-time. Emitted pollutants such as NO are kept below this inversion, which may have origin in the NOx concentration to increase during the night (Han et al. 2011). This mound in the temporal variability of air pollutants can be found in cities worldwide (Sanchez et al. 2007).

The diurnal variation for different seasons (Fig. 3) shows equitable consistency with high NO_2 concentration levels during night-time and low values during the daytime.

Seasonal average of monthly values of NO_2: The seasonal averages of monthly values of NO_2 concentration observed for a period of October 2014-September 2015 are shown in Fig. 4. It is inferred that all the four seasons recorded analo-

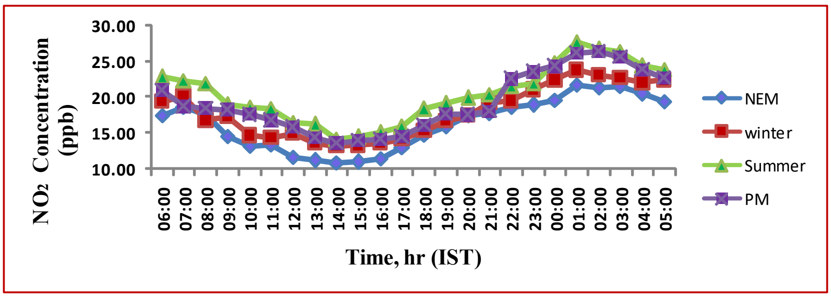

Fig. 3: Average seasonal diurnal variation at the study area (October 2014-September 2015).

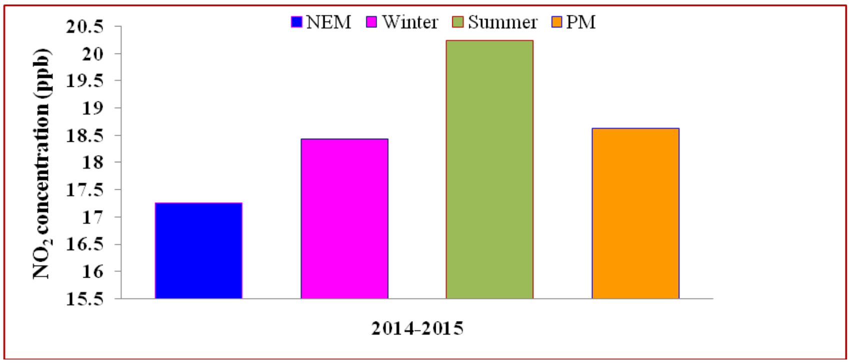

Fig. 4: Seasonal average of monthly values of NO_2 at the study area (October 2014-September 2015).

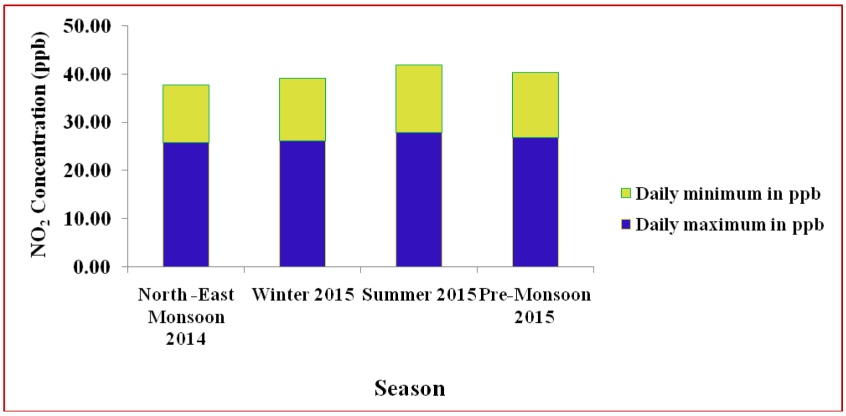

Fig. 5: Seasonal average of daily max and minimum values of NO_2 at study area (October 2014-September 2015).

gous pattern for the entire period of observation. From Fig. 4, it is quite clear that the summer season recorded the highest values of NO_2 concentration and slightly decreased in the following pre monsoon (PM) season. The lowest values of NO_2 are always associated with the northeast monsoon. A slight increase in the value of NO_2 is noted in winter as compared to the north-east monsoon. From this specific outcome, it is induced that there is no occurrence of anomalous production of NO_2 at any season during the period of study and subsequently the moderate NO_2 outflow turns into the normal for the investigation territory.

Seasonal average of daily maximum and minimum values of NO_2: Fig. 5 illustrates the schematic representation of averages of daily maximum and minimum values season-wise during the study period at study area. From Fig. 5, it is learnt that both the daily minimum and maximum values observed to be highest in summer, slightly reduced in pre-monsoon, lowest during north-east monsoon and slightly increased in the following winter.

CONCLUSION

The NO_2 measurement in the study area during the study period from October 2014-September 2015 has been analysed on a diurnal and seasonal scale. The frequency distribution of NO_2 concentration reveals about 86% 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 0-5 ppb. The NO_2 concentration level is found high in summer and low in the north-east monsoon. On seasonal average, the daily minimum and maximum values observed to be highest in summer and lowest in north-east monsoon.

Concerted study on the NO_2 concentration at Ashok Pillar in an urban coastal location Chennai brings forth the first hand information on the atmosphere. The characteristic properties are well understood. It illustrates the healthy atmospheric condition. Even though the NO_2 concentration levels are below the National Ambient Air Quality standard at present, it has the potential to increase in near future as a result of increased anthropogenic activities. It prompts the need to monitor the environment continuously and to create awareness for the conservation of the vital atmospheric trace constituent, the NO_2 within the permissible limit. Knowing the current levels of these pollutants is essential to create awareness and mitigate them. So, their continuous monitoring is inevitable.

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